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Technical and Economic Evaluation of BATEA Textile Guidelines

American Textile Manufacturers Inst.,
Washington, DC

Prepared for

Industrial Environmental Research Lab.
Research Triangle Park, NC

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16. ABSTRACT

The report gives results of a project to determine if the Best Available Technology Economically Achievable (BATEA) effluent guidelines promulgated by EPA in 1974 for the textile industry can be achieved by recommended advanced wastewater tertiary treatment technologies. Pilot scale treatment units in two identical trailers were used at 19 textile plants participating in the field evaluation phase of the project. The unit operations were tested on biologically treated effluent from existing facilities at each plant. The most effective treatment was identified for each plant and operated continuously long enough to statistically determine the quality of the treated effluent. In all cases results were compared to BATEA values calculated from the promulgated guidelines and actual production information from the plants during the trailer visits. The comparisons indicated that technical achievement of the BATEA guideline limits for the various criteria pollutants was not consistent in all categories. The cost of installing and operating the selected BATEA tertiary operations in commercial textile plants was determined and guidelines for estimating these costs were established.

17. KEY WORDS AND DOCUMENT ANALYSIS

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Textile Processes	BATEA	13H
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by

R.E. Mayfield, T.N. Sargent,
and E.J. Schroeder (Engineering Science, Inc.)

American Textile Manufacturers Institute
1101 Connecticut Avenue, NW (Suite 300)
Washington, DC 20036

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EPA Project Officer: Max Samfield

Industrial Environmental Research Laboratory
Office of Environmental Engineering and Technology
Research Triangle Park, NC 27711

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FOREWORD

Regulations for controlling the discharge of pollutants in textile wastewaters were issued in July 1974 following more than 2 years of effort between the industry and the Environmental Protection Agency. The regulations established two levels of control to be met by 1977 and 1983. The 1977 limitations were to be achieved through the application of the Best Practicable Control Technology Currently Available (BPT) while the stricter 1983 limitations were to be met through the use of the Best Available Technology Economically Achievable (BATEA).

The industry generally accepted the 1977 BPT limits, but had serious reservations with its ability to meet the 1983 levels. The industry's reservations were based on the possible high capital expenditure requirements, associated operation and maintenance costs and on the knowledge that many of the technologies proposed by EPA had not been adequately evaluated in the textile industry.

In October 1974, the American Textile Manufacturers Institute (ATMI) petitioned the Fourth U.S. Circuit Court of Appeals for review of the 1983 regulations and was joined in this action by the Northern Textile Association (NTA) and the Carpet and Rug Institute (CRI). The industry groups and EPA subsequently filed a joint motion requesting an indefinite stay of the petition to allow for further evaluation of the regulations. During this time, ATMI proposed a joint effort with EPA in a long-range study to determine the technical and economic achievability of the BATEA limitations.

In January 1976, EPA awarded a grant to the industry for a 30-month two-phase engineering and economic study. The first phase was to cover engineering studies including the design, construction and field operation of two mobile wastewater treatment units at 19 textile plants representing 6 of 7 industry subcategories established by the Agency. The second phase was to provide for a broad economic study of the costs and impact of applying the technologies of the field study to the overall industry.

At EPA's subsequent request, the scope of the investigations under the grant were generally limited to the field engineering studies. Evaluation of the economic impact of applying the BATEA guidelines was conducted as a companion study by the industry. A report on this study will be issued by the joint industry groups through the American Textile Manufacturers Institute.

O'Jay Niles
Director of Government Regulations/Regulatory
American Textile Manufacturers Institute

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American Textile Manufacturers Institute (ATMI)

ATMI Staff

Mr. W. Ray Shockley, Executive Vice-President
Mr. F. Sadler Love, Secretary-Treasurer
Mr. O'Jay Niles, Project Manager and Director-Government Affairs/Regulatory

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Mr. W. L. Roark (Greenwood Mills)
Mr. W. I. (Ike) English (Burlington Industries, Inc.), Retired
Mr. J. D. Lesslie (Springs Mills, Inc.), Retired

ATMI Task Group Members

Mr. T. A. Alspaugh (Cone Mills Corp.)
Mr. R. M. Allen (Milliken Service Corp.)
Mr. S. H. Griggs (J. P. Stevens & Co., Inc.)
Mr. M. Bahorsky (Institute of Textile Technology)
Mr. F. T. Eslick (American Thread Corp.)
Mr. R. A. Harden, Jr. (Fieldcrest Mills, Inc.)
Mr. R. Thornberry (American Thread Corp.)
Mr. J. S. Ameen (Burlington Industries, Inc.), Deceased

The Carpet and Rug Institute (CRI)

Mr. C. B. Torrence, Director of Technical Services

Northern Textile Association (NTA)

Mr. W. F. Sullivan, President, Deceased
Mr. K. Spilhaus
Mr. W. B. Ball, Chairman-NTA Environmental Advisory Committee

U.S. Environmental Protection Agency (EPA)

EPA Office of Energy, Minerals and Industry

Dr. D. A. Denny
Dr. M. Samfield (Project Officer)
Mr. J. Kernan
Mr. J. Fincke

EPA Office for Water and Waste Management Effluent Guidelines Division

Mr. R. B. Schaffer
Mr. J. Riley
Dr. J. D. Gallup
Mr. J. R. Berlow

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CHAPTER I

INTRODUCTION

GENERAL PROJECT BACKGROUND

On February 5, 1974 notice was given in the FEDERAL REGISTER (39 FR 4628) that the U.S. Environmental Protection Agency (EPA) would propose point source pollutant discharge guidelines limitations for the textile industry. These limitations would define discharge limits for existing textile plants and establish standards of performance for new sources involved in wool scouring, wool finishing, dry processing, woven fabric finishing, knit fabric finishing, carpet manufacture and stock and yarn dyeing and finishing activities. On July 5, 1974 EPA published in the FEDERAL REGISTER (Vol. 39 - No. 130) Effluent Guidelines and Standards for textile industry point source dischargers. These guidelines required Best Practicable Control Technology Currently Available (BPT) to be met by July 1, 1977 and Best Available Technology Economically Achievable (BATEA) to be achieved by July 1, 1983. Further definitions of and modifications to the guidelines were published in the FEDERAL REGISTER of August 26, 1974. The BPT and BATEA effluent guideline limitations for existing sources are summarized in Tables 1 and 2, respectively.

On October 1, 1974 the American Textile Manufacturers Institute (ATMI) filed a petition for review of the textile industry BATEA guidelines with the U.S. Fourth Circuit Court of Appeals. ATMI was joined in this action by the Northern Textile Association (NTA) and the Carpet and Rug Institute (CRI). The parties involved subsequently filed a joint motion to delay the petition pending the review of the results of a cooperative study undertaken to evaluate the technical and economic achievability and impact on the textile industry of the promulgated BATEA discharge limitations.

PROJECT OBJECTIVES

The objective of the cooperative study was to evaluate the treatment efficiency of processes identified as Best Available Technology Economically Achievable by EPA's Effluent Guidelines Division on textile industry wastewaters. Engineering-Science, Inc. (ES) was selected as the technical contractor to accomplish this objective. The technical study has now been completed and the results are presented in this report.

TABLE 1

BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE - 1974(1)

SUBCATEGORY	30-Day Average - lb pollutant/1000 lb production(2)					
	BOD_5	COD	TSS	TOTAL CHROME	PHENOLS	SULFIDES
A. Wool Scouring (3)	5.3	69.0	16.1	.05	.05	.10
B. Wool Finishing	11.2	81.5	17.6	.07	.07	.14
C. Dry Processing	0.7	1.4	0.7	---	---	---
D. Woven Fabric Finishing(4a)	3.3	30.0	8.9	.05	.05	.10
E. Knit Fabric Finishing(4b)	2.5	30.0	10.9	.05	.05	.10
F. Carpet Mills(4c)	3.9	35.1	5.5	.02	.02	.04
G. Stock & Yarn Dyeing and Finishing	3.4	42.3	8.7	.06	.06	.12

RANGE OF pH FOR ALL SUBCATEGORIES - 6.0 to 9.0

(1) The BPT guidelines were promulgated by EPA on July 5, 1974 and became effective July 1, 1977. Best practicable treatment implies a level of treatment equivalent to biological activated sludge

(2) **Daily maximum not to exceed twice the 30-day average.**

(3) **Oil and grease limitation for Wool Scouring subcategory is 3.6 lb./100 lb. production**

(4) Additional COD limitation allowed for:

a. Woven Fabric Finishing through --

(1) Simple process with synthetic fiber or complex process with natural fiber	10 lb/1000 lb
(2) Simple process with natural/synthetic blend or Complex process with synthetic fiber	20 lb/1000 lb
(3) Complex process with natural/synthetic blend	30 lb/1000 lb

b. Knit Fabric Finishing through --

(1) Simple process with natural/synthetic blend or Complex process with synthetic fiber	10 lb/1000 lb
(2) Complex process with natural/synthetic blend	20 lb/1000 lb

c. Carpet Mills through --

(1) Complex manufacturing process	10 lb/1000 lb

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TABLE 2

BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

DISCHARGE LIMITATIONS - 1974[(1)]

		30-Day Average - lb pollutant/1000 lb production[(2)]					
SUBCATEGORY	BOD_5	COD	TSS	TOTAL CHROME	PHENOLS	SULFIDES	COLOR[(3)]
A. Wool Scouring[(4)]	2.4	18.0	2.0	.05	.05	.10	600
B. Wool Finishing	4.6	27.1	2.5	.07	.07	.14	600
C. Dry Processing	0.2	0.4	0.2	---	---	---	---
D. Woven Fabric Finishing[(5a)]	2.2	10.0	1.5	.05	.05	.10	300
E. Knit Fabric Finishing [(5b)]	1.7	10.0	1.7	.05	.05	.10	300
F. Carpet Mills[(5c)]	2.0	11.7	1.0	.02	.02	.04	225
G. Stock & Yarn Dyeing & Finishing	2.3	14.1	1.9	.06	.06	.12	300

RANGE OF pH FOR ALL SUBCATEGORIES - 6.0 to 9.0 FECAL COLIFORM FOR ALL SUBCATEGORIES - MPN NOT TO EXCEED 400 COUNTS PER 100 ml

(1) The BATEA guidelines were promoulgated by EPA on July 5, 1974 and are scheduled to become effective on July 1, 1983. Best available technology economically achievable implies a level of treatment equivalent to biological activated sludge followed by advanced waste treatment.

(2) Daily maximum not to exceed twice the 30-day average.

(3) Maximum color limitation as measured by ADMI method.

(4) For Wool Scouring - Oil and grease limitation = 1 lb/1000 lb production.

(5) Additional COD limitations allowed for:
- a. Woven Fabric Finishing through --
  - (1) Simple process with synthetic fiber or Complex process with natural fiber 3.3 lb/1000 lb
  - (2) Simple process with natural/synthetic blend or Complex process with synthetic fiber 6.7 lb/1000 lb
  - (3) Complex process with natural/synthetic blend 10.0 lb/1000 lb
- b. Knit Fabric Finishing through --
  - (1) Simple process with natural/synthetic blend or Complex process with synthetic fiber 3.3 lb/1000 lb
  - (2) Complex process with natural/synthetic blend 6.7 lb/1000 lb
- c. Carpet Mills through --
  - (1) Complex manufacturing process 3.3 lb/1000 lb

PROJECT ORGANIZATION

Project organization was structured such that ATMI, NTA and CRI were represented by the ATMI Environmental Preservation Committee. Dr. Max Samfield was assigned to represent the EPA as Project Officer. Mr. O'Jay Niles, Project Manager, was responsible for the conduct of the study and reported to the Environmental Preservation Committee and the EPA Project Officer. The technical consultant was responsible for experimental operations and reporting and reported to the Project Manager. Several task groups were formed to provide technical guidance for the consultant. A project organization chart is presented in Figure 1.

TECHNICAL STUDY

The technical phase of this study consisted of defining the Advanced Waste Treatment (AWT) processes to be tested, designing and constructing pilot units, surveying and selecting textile plants for pilot plant study, performing pilot plant studies, evaluating pilot plant data and preparing conceptual BATEA plant designs, developing key aspects of the cost functions for estimating BATEA costs and preparing project reports.

Selection of Representative Textile Plants

To insure the success of the study and validity of results, it was necessary to select a group of plants that would be representative of the textile dyeing and finishing industry. The EPA groups textile plants into subcategories according to types of production activity. Table 3 shows the EPA's subcategory designations as well as the type of production associated with each. Also given are the number of plants where AWT experimentation was done. The following criteria were used to select the participating plants:

a. The textile mills must have operating secondary wastewater treatment facilities.

b. The effluent from the existing wastewater treatment facilities must be generally within NPDES permit levels.

c. The wastewater treatment effluent must normally be discharged directly to a natural water course.

d. The textile manufacturing company must be willing to participate in the study (financially and otherwise).

e. The textile mill must be located such that it was compatible with location and other constraints of the study activities.

The selections were made from a group of candidate plants identified by ATMI. These plants were coded to maintain confidentiality of production data and other site specific information.

TABLE 3

SUBCATEGORIES WITHIN THE TEXTILE INDUSTRY[(1)]

EPA DESIGNATION	PRODUCTION ACTIVITY	NUMBER OF PLANTS IN SUBCATEGORY INCLUDED IN PILOT PLANT STUDY	NUMBER OF PLANTS IN SUBCATEGORY (EPA MASTER LIST)[(2)]
SUBCATEGORY I (A)	Wool Scouring	1	17
SUBCATEGORY II (B)	Wool Finishing	2	37
SUBCATEGORY III (C)	Dry Processing	0	612
SUBCATEGORY IV (D)	Woven Fabric Finishing	10	336
SUBCATEGORY V (E)	Knit Fabric Finishing	3	282
SUBCATEGORY VI (F)	Carpet Mills	1	58
SUBCATEGORY VII (G)	Stock and Yarn Dyeing and Finishing	2	217

(1) Subcategories as defined by EPA on July 5, 1974.

(2) Derived from information contained in "Technical Study Report, BATEA-NSPS-PSES-PSNS; Textile Mills, Point Source Category", prepared for the U.S. EPA, Contract Nos. 68-01-3289 and 68-01-3884, November, 1978.

AWT Pilot Survey of Selected Textile Mills

Engineering-Science designed and constructed two mobile pilot units. The experimental equipment was built into 40-ft. trailers to facilitate relocation from one textile plant to another. The trailers contained all equipment necessary to test the following AWT processes on a pilot scale.

Chemical Coagulation/Clarification

Multi-Media Filtration (with and without pre-filter coagulant addition)

Granular Activated Carbon Adsorption

Ozonation

These AWT processes could be tested individually or in combination with each other. Dissolved Air Flotation (DAF) was also tested with bench-scale equipment. More specific information on the pilot plant units and the experimental testing are contained in Chapters IV and V of this report.

The pilot plants visited a total of 19 textile mills between May, 1977 and September, 1978. Experimentation was done to first screen potential treatment processes, and then to collect sufficient continuous operation data on candidate processes for the development of preliminary design criteria. A report presenting experimental results was written and issued for each of the 19 textile plants visited. Key portions of these plant reports are presented in Appendix C of this report. The experimental results of the study are summarized in Chapters V and VI.

Analytical Quality Assurance Program

The pilot units were equipped with apparatus to perform certain analyses basic to operational control. The bulk of the analyses, however, was conducted at five independent laboratories under contract to ATMI.

To assure the quality of the analytical data generated from this study, a Quality Assurance (QA) program was organized and administered by ES during the course of this study. Methods employed to determine accuracy of laboratory results include duplicate samples, split samples, spiked samples and reference samples. The five support laboratories as well as the ES Atlanta laboratory were involved in the QA program. QA results were presented in quarterly reports during the course of the study and corrective measures were taken when required.

Carbon Regeneration Experiments

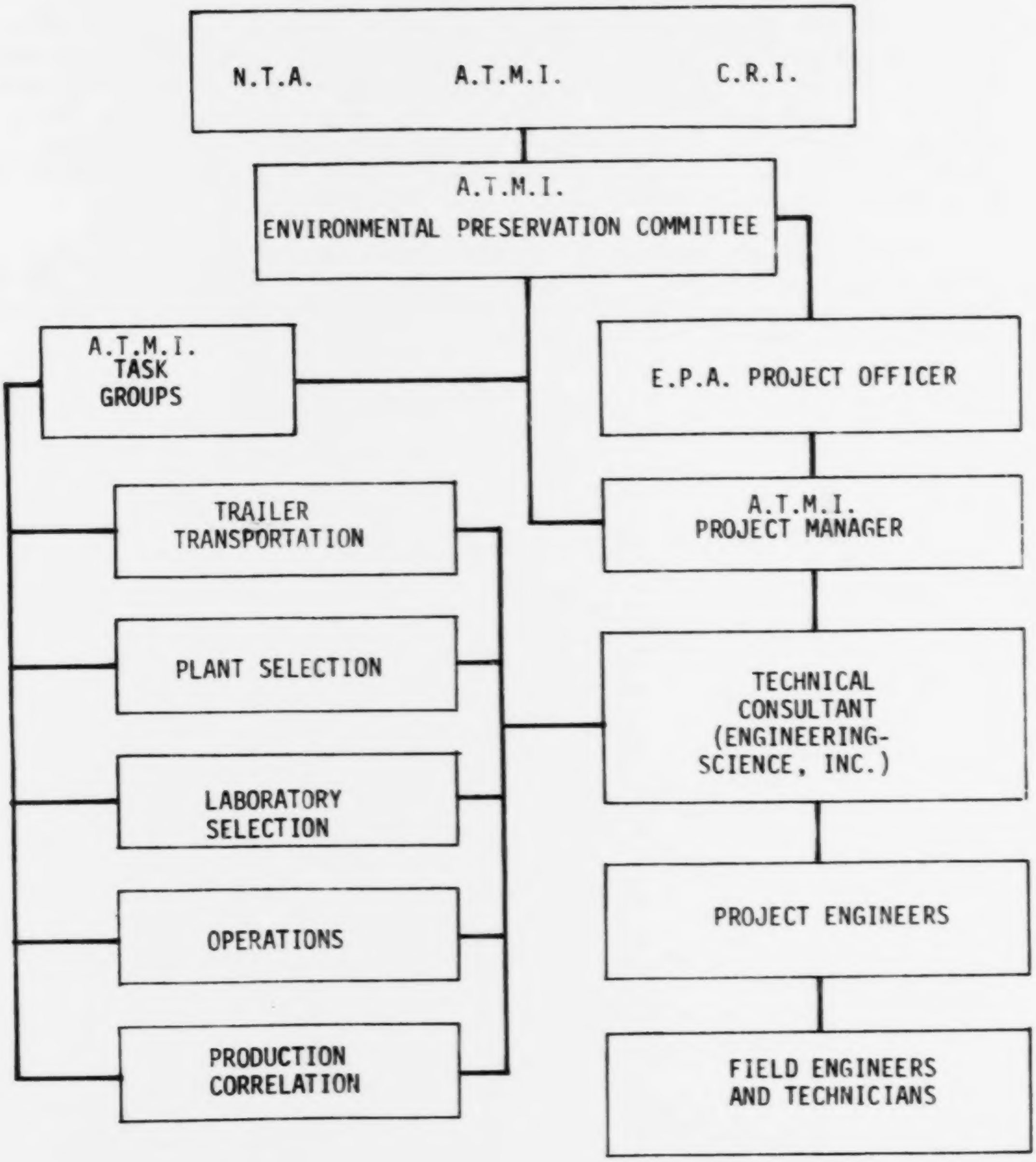
Bench-scale regeneration experiments were conducted on samples of exhausted granular activated carbon from carbon contact experimentation at 12 of the textile plants visited. These tests were performed by Westvaco Corporation Chemical Division of Covington, Virginia. The results of these experiments are given in Appendix D of this report.

Powdered Activated Carbon in Activated Sludge Experiments

The powdered activated carbon in activated sludge (PAC) process was tested with ten textile plant wastewaters during the course of this study. Bench-scale bioreactors were operated in the ES Atlanta laboratory utilizing raw influent provided by the textile mills. The objective of this portion of the study was to evaluate the potential of meeting BATEA effluent limitations by converting existing secondary biological processes into PAC processes. The results of this phase of study were presented in a report issued in May, 1978. Conclusions and observations from the bench-scale PAC experiments are included as Appendix E of this report.

The initial bench-scale PAC studies indicated that this technology appeared to be a feasible AWT process alternative for achieving the BATEA guideline limitations. Therefore, additional pilot plant testing was recommended at Subcategory IV and V plants.

FIGURE 1. PROJECT ORGANIZATION CHART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CHAPTER II

CONCLUSIONS FROM THE TECHNICAL STUDY

The objective of this study was to conduct pilot-scale testing of the selected AWT technologies (coagulation/clarification, multi-media filtration, granular carbon adsorption and ozonation) to treat BPT effluents at textile plants selected from the various manufacturing subcategories within the industry. Based on data obtained from field experimentation, the treatment effectiveness of the various AWT technologies was determined for achieving the July 5, 1974 BATEA guideline values. (All references in this report to BPT and BATEA guideline values are those published in 1974.)

The pilot plant tests have been completed at the 19 textile plants selected to participate in the study. The data has been summarized and evaluated in this report. It is noteworthy that this is the most extensive study conducted to date on advanced waste treatment of textile mill wastewaters. It was not possible, however, to thoroughly evaluate all factors that influence textile wastewater treatment; especially basic changes in production techniques, fibers processed, and severe wintertime conditions. The following conclusions and observations were developed based on the results of this study.

1. Of the 19 plants tested, ten (53 percent) could meet the BATEA guideline values with one or more of the AWT process technologies. Nine of the plants (47 percent) failed to meet the BATEA guideline values with any combination of AWT process technologies evaluated. The ability of the AWT processes to achieve the BATEA guidelines was judged based on statistically predicted 30-day average and maximum day effluent concentrations. The predicted 30-day average values ranged from 1.0 to 2.3 times the average measured AWT effluent concentration with the mean being 1.2. The predicted maximum day values ranged from 1.0 to 3.0 times the average measured AWT effluent concentration with the mean being 1.3.
2. Of the test plants selected as having typical secondary treatment facilities generally achieving their NPDES permit values, eight (42 percent) failed at the time of pilot plant operations to achieve the BPT guideline values when related to actual short-term production figures. The secondary treatment facilities at the plant sites selected generally appeared to be designed and operated at a performance level consistent with BPT technology. Relationships between achievement of BPT and BATEA guideline values during pilot experimentation among the 19 plants visited were distributed in the following way:

Of the 19 plants visited, 11 were able to achieve the BPT effluent guidelines with the existing secondary facilities. Of these plants, seven were able to meet BATEA limits with AWT, and four were not able to meet BATEA limits with AWT.

Of the 19 plants visited, eight were not able to achieve the BPT effluent guidelines with the existing secondary facilities. Of these plants, three were able to meet BATEA limits with AWT and five were not able to meet BATEA limits with AWT.

3. The treatment effectiveness of the AWT process technologies applied to secondary effluents of the 19 selected textile plants participating in the pilot plant study is summarized in Table 4 and discussed by subcategory below.

Subcategory I (Wool Scouring) - Of the four candidate AWT process systems tested at the one selected site, additional clarification followed by multi-media filtration followed by granular carbon adsorption was the recommended AWT treatment system that successfully achieved the currently promulgated BATEA guideline values.

Subcategory II (Wool Finishing) - Of the six candidate AWT process systems tested at the two selected sites, both coagulation/clarification followed by multi-media filtration (where BPT TSS values were high) and multi-media filtration followed by granular carbon adsorption (where BPT TSS values were low) were selected as the recommended AWT treatment systems. At the site where coagulation/clarification followed by filtration was the recommended process, all BATEA limits were achieved. At the site where filtration followed by activated carbon was selected, all BATEA limits except sulfide were achieved.

Subcategory III (Dry Processing) - No sites were tested in this subcategory because of the low level of pollutants discharged from dry processing.

Subcategory IV (Woven Fabric Finishing) - Of the candidate AWT process systems tested at the ten selected sites, multi-media filtration followed by granular carbon adsorption or a process system including multi-media filtration and granular carbon adsorption was the recommended AWT treatment system for a majority of the plants tested (seven out of ten). The BPT guidelines were being achieved at six of the ten Subcategory IV plants. The 1974 BATEA guidelines were achieved with these AWT technologies at three of the plants tested. Seven of the plants could not meet the guidelines using these technologies.

Subcategory V (Knit Fabric Finishing) - Of the six candidate AWT process systems tested at the three selected plants, multimedia filtration or multi-media filtration followed by granular

TABLE 4

SUMMARY OF PILOT PLANT TEST RESULTS

SUB-CATEGORY	PLANT	BPT †† GUIDELINES		AWT PROCESSES														BATEA * TREATMENT OBJECTIVES	ABILITY TO ACHIEVE BATEA W/ RECOMMENDED PROCESS (EXCEPTIONS) †
		MET	NOT MET	1 R/C	2 MMF	3 MMF W/PRECOAG.	4 R/C MMF	5 MMF + O_3	5A MMF W/PRECOAG. + O_3	6 R/C O_3	7 R/C MMF O_3	8 MMF CC	8A MMF W/PRECOAG. CC	9 R/C MMF CC	10 MMF CC O_3	11 R/C MMF CC O_3			
I	A	YES		●			▣				●			◉				1	YES
II	O	NO	SUL	●	●		▣	●				◉						5	NO (SUL)
	B	NO	BOD, TSS, COD	●			□◉							●				2	YES (BOD/1)
III	NO SITES TESTED																		
IV	D	NO	COD, TSS		●		□					●			◉			3	NO (BOD, COD, COLOR)
	P	YES			◉	●	□						●					4	YES (TSS/3)
	V	NO	COD, BOD, TSS	●			▣					●		◉				5	NO (COD, TSS)
	Y	NO	TSS, COD		●		□					◉						2	YES
	Z	YES			●	●	□		●			◉						6	NO (COD)
	AA	NO	BOD, TSS				□		●				◉					6	NO (COD)
	BB	YES		●	●		▣					◉						3	NO (TSS, COD)
	DD	YES			●	◉	□					●						1	NO (TSS)
	T	YES			●		□					◉						1	NO (COD, TSS)
	K	YES				◉	□	●				●						8	YES
V	W	YES			◉	●	□					●						7	YES (TSS/1)
	Q	NO	COD	●	●	●	▣	●				◉						5	YES
	E	YES		●	●		▣					◉						5	YES
VI	F	YES		●			□◉							●				3	YES
VII	S	NO	BOD	●	●		□◉					●						5	NO (COD, TSS)
	EE	YES		●	◉		▣	●				●						8	YES

LEGEND:
- ● AWT PROCESS TESTED
- O RECOMMENDED PROCESS FROM ATMI STUDY
- □ RECOMMENDED PROCESS FROM EPA GUIDELINES ISSUED IN 1974

R/C - REACTOR/CLARIFIER
MMF - MULTI-MEDIA FILTER
MMF W/PRECOAG - MULTI-MEDIA FILTER WITH PRECOAGULATION
O_3 - OZONE
CC - CARBON

* PARAMETER CODES

1. TSS, COD
2. BOD, COD, TSS, CHR. & COLOR
3. COD, TSS, COLOR
4. TSS
5. BOD, COD, TSS
6. BOD, COD, TSS, COLOR
7. BOD, TSS
8. ALL PARAMETERS MET

† (EXCEPTION PARAMETER/mg/1 OVER BATEA VALUE)

†† BASED ON DURATION OF PILOT PLANT OPERATIONS. BOTH TEXTILE DATA AND SUPPORT LAB DATA CONSIDERED.

carbon adsorption was the recommended AWT treatment system that successfully achieved the BATEA guideline values.

Subcategory VI (Carpet Mills) - Of the three candidate AWT process systems tested at the one selected plant, coagulation/clarification followed by multi-media filtration was the recommended AWT treatment system that successfully achieved the BATEA guideline values.

Subcategory VII (Stock and Yarn Dyeing) - Of the five candidate AWT process systems tested at the two selected plants, multi-media filtration (where the BPT TSS and COD were low) or coagulation/clarification followed by multi-media filtration was the recommended AWT treatment system. However, the BATEA guideline values could not be achieved with these AWT technologies at one of the two plants tested.

4. The treatment effectiveness of the individual AWT processes is discussed in the following subsections. The process design parameters for the candidate AWT processes tested are summarized in Table 5.

Coagulation/clarification was a candidate process in Subcategories II, V, VI and VII plants and demonstrated reasonable treatment effectiveness for reduction of most of the parameters measured. However, coagulation/clarification was not a feasible process in Subcategories I and IV plants due to the inability to identify an effective coagulant or very high coagulant dosage requirements.

Multi-media filtration performed well in most cases for TSS removal. If the TSS value of the BPT effluent was approximately 100 mg/l or less, then multi-media filtration was effective as an initial process for TSS reduction. Multi-media filtration was also an effective process for reducing TSS after coagulation/clarification.

Granular carbon adsorption performed well when compared to other AWT processes for organic and color removal in Subcategories I, II, IV, V and VI. However, granular carbon adsorption was not effective in achieving the BATEA guideline values at one of the two Subcategory VII plants, nor at six of the ten Subcategory IV plants. In some cases, it was observed that a portion of the organic removal occurred from physical filtering rather than an adsorption mechanism. In certain instances, soluble organics were re-introduced into the waste stream as a result of desorption.

Ozonation did achieve color reduction below the BATEA guideline values at selected sites, but did not reduce COD below the BATEA limits.

TABLE 5

SUMMARY OF DESIGN PARAMETERS FOR CANDIDATE AWT PROCESSES(1)

AWT PROCESS	PARAMETER	SUBCATEGORY					
		I	II	IV	V	VI	VII
Coagulation/ Clarification	Overflow Rate, gpd/ft^2	400	400	(3)	400	400	400
	Coagulant(2)	-	Alum	(3)	Alum	C.P.	Alum
	Coagulant Dosage, mg/l	-	21	(3)	20	35	25
	Underflow Rate, %	10	10	24	3	8	3
	Sites tested in Subcategory	1 of 1	2 of 2	2 of 10	2 of 3	1 of 1	2 of 2
Multi-Media Filtration (BPT)	Surface Loading, gpm/ft^2	(3)	3	4	4	(3)	6
	Sites tested in Subcategory	0 of 1	1 of 2	7 of 10	3 of 3	0 of 1	2 of 2
Multi-Media Filtration (after coagulation/ clarification	Surface Loading, gpm/ft^2	2	4.2	2.3	4	5	4
	Sites tested in Subcategory	1 of 1	2 of 2	2 of 10	2 of 3	1 of 1	2 of 2
Multi-Media Filtration with Precoagulation	Surface Loading, gpm/ft^2	(3)	(3)	2.5	2.5	(3)	(3)
	Coagulant(2)			Alum	Alum		
	Coagulant Dosage, mg/l			8	1		
	Sites tested in Subcategory	0 of 1	0 of 2	4 of 10	2 of 3	0 of 1	0 of 2
Granular Carbon Adsorption	Carbon Capacity, lb COD$_5$/lb Carbon	0.155	0.230	0.110	0.250	0.300	0.180
	Contact Time, min.	45	45	45	45	45	45
	Sites tested in Subcategory	1 of 1	2 of 2	10 of 10	3 of 3	1 of 1	2 of 2
Ozonation	Contact Time, min.	45	33	25	45	(3)	45
	lb COD$_5$ removed per lb O_3 utilized	0.304	0.327	0.500	0.142		0.367
	Sites tested in Subcategory	1 of 1	1 of 2	4 of 10	1 of 3	0 of 1	1 of 2

(1) The operating parameters presented here were derived from subcategory averages used during continuous candidate experimentation. All technologies were screened at each plant but ineffective ones were not tested on a continuous basis.

(2) C.P. = Cationic Polymer; Alum expressed as mg Al^{+3}/l

(3) Process did not demonstrate any reasonable treatment.

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The feasibility of the powdered activated carbon in activated sludge process (PAC) was evaluated on wastewaters from each of the subcategories on laboratory scale. Based on favorable results of the laboratory scale testing, pilot testing was recommended for Subcategories IV and V plants.

Dissolved air flotation (DAF) was not found to be as effective a method for TSS reduction as the coagulation/clarification process. Only at two sites did the coagulation/DAF batch experiments indicate results comparable to those from continuous operation of pilot-scale coagulation/clarification.

5. In general, phenol, chromium and sulfide were not a treatment problem because secondary effluent levels were low. Only one plant could not meet the BATEA limitation for sulfide; all plants met the limits for phenol and chromium with the application of AWT. For 18 of the 19 plants visited, secondary effluents were below the BATEA limits (unchanged from the BPT guideline limitations) for these parameters. The currently promulgated BATEA guideline values for BOD_5 and color can be achieved in the majority of cases with the addition of AWT technology (17 out of the 19 sites in the study achieved the guidelines for these parameters with the application of AWT).

   The BATEA guideline values for COD can be achieved with AWT technology in most Subcategory I (Wool Scouring), II (Wool Finishing), V (Knit Finishing) and VI (Carpet Mills) plants. Of the ten plants visited in Subcategory IV (Woven Fabric Finishing), four met the BATEA COD limitation with the application of AWT. If the COD guideline value in Subcategory IV were increased by 38 percent then all but two of the ten study plants could have achieved the COD guideline value. Of the two plants visited in Subcategory VII (Stock and Yarn Dyeing), one met the BATEA COD limitation with the application of AWT. If the COD guideline value in Subcategory VII were increased by 25 percent then both study plants could have met the COD guideline value.

   The currently promulgated BATEA guideline values for TSS can be achieved with AWT technology in most Subcategory I (Wool Scouring), II (Wool Finishing), V (Knit Finishing) and VI (Carpet Mills) plants. Of the ten plants visited in Subcategory IV (Woven Fabric Finishing), five met the BATEA TSS limitation with the application of AWT. If the TSS guideline value in Subcategory IV were increased 37 percent then all but two of the ten study plants could have achieved the TSS guidelines value. Of the two plants visited in Subcategory VII (Stock and Yarn Dyeing), one met the BATEA TSS limitation with the application of AWT. If the TSS guideline value for Subcategory VII were increased 78 percent then both plants could achieve the BATEA guideline value.

6. Nineteen textile plants were selected for this study. Ten plants were selected from Subcategory IV, three from Subcategory V, two each from Subcategories II and VII, and one each from Subcategories I and VI. No plants were selected from Subcategory III (Dry Processing). The proportions were based on the number of mills in the industry within each subcategory and the process complexity of the subcategory. More plants were selected from Subcategory IV because this subcategory exhibits the highest degree of variability from plant to plant in production processes, dyes, finishes and fibers, and represents the largest single segment of the industry.

   Two textile mills visited during the study (Plant K; Subcategory IV and Plant EE; Subcategory VII) were found, after pilot plant arrival, to be engaged in production practices that were atypical of their respective subcategories. It is believed that these production practices affected the raw wastewater stream and thus wastewater treatment at these plants.

   The following observations concern the individual plants visited during the course of the study:

   SUBCATEGORY I (Wool Scouring)

   Plant A - No effective coagulant was found for use with the reactor/clarifier or as a prefilter aid. The clarifier was operated without coagulant and provided some TSS removal. The recommended AWT process was additional clarification followed by filtration followed by granular activated carbon.

   SUBCATEGORY II (Wool Finishing)

   Plant O - The selected AWT process train was multi-media filtration followed by granular activated carbon. This was the only textile mill visited where AWT processes were unable to reduce sulfide below BPT and BATEA limits.

   Plant B - A large percentage of the wool used for production at Plant B comes from recycled woollen goods. Coagulation/clarification followed by multi-media filtration was the recommended AWT process. Even though lime was added along with alum to help reduce sludge volume, an underflow rate of 25 percent of the treated flow was required to control the sludge blanket.

   SUBCATEGORY IV (Woven Fabric Finishing)

   Plant D - Multi-media filtration followed by granular activated carbon followed by ozonation was the recommended AWT process. This was one of the few plants where the BATEA color guideline values could not be achieved. Ozonation was used to reduce color to a level that was close to the limit. This process had the negative effect of increasing the secondary effluent BOD_5

(below the BATEA limit before AWT) to a concentration above the guideline value.

Plant P - The secondary treatment facility at Plant P was achieving all BATEA guideline limits except TSS. Multi-media filtration alone was selected as the AWT treatment process. The projected 30-day average effluent (90th percentile value) exceeded the BATEA TSS limit by 3 mg/l or 0.3 kg/kkg.

Plant V - The secondary effluent at Plant V during pilot plant operations was highly variable. High effluent TSS concentrations made operation of the reactor/clarifier and multi-media filter very difficult. The recommendation was made to take steps to improve secondary plant operations. Coagulation/clarification followed by multi-media filtration followed by granular activated carbon is projected as the AWT technology once the secondary TSS fluctulations can be controlled.

Plant Y - The BATEA effluent guideline limitations were achieved with application of multi-media filtration followed by granular activated carbon.

Plant Z - The recommended AWT process was multi-media filtration followed by granular activated carbon, even though granular carbon adsorption was not a very effective technology at this plant. The phenomena of organic desorption/displacement was observed. The selected AWT process was unable to achieve the BATEA COD limitation.

Plant AA - During pilot operations at Plant AA there was a rather drastic change in secondary plant effluent. The occurrence was marked by a change in wastewater color and an immediate color and COD breakthrough across the pilot plant carbon columns. It was determined that this occurrence was a result of the processing of overdyed and reworked fabrics within the textile mill. This is a regular occurrence and must be accounted for in wastewater treatment operations. The recommended AWT process was multi-media filtration with pre-filter coagulation followed by granular activated carbon adsorption.

Plant BB - Plant BB production is classified at 100 percent "commission finishing". This was the only textile mill visited during this study with this status. The coagulant demand for coagulation/clarification was excessively high and a 40 percent underflow (based on the treated flow rate) was required to operate the reactor clarifier. The selected AWT process was multi-media filtration followed by granular activated carbon.

Plant DD - The two candidate processes at Plant DD were multi-media filtration with pre-coagulation and multi-media filtration followed by granular activated carbon. Multi-media filtration with pre-coagulation was selected as the AWT process based on an economic comparison.

Plant T - Multi-media filtration followed by granular activated carbon adsorption was the recommended AWT treatment process. The BATEA limitations for COD and TSS were not achieved but the selected technology was superior to the others tested from a treatment effectiveness point of view.

Plant K - The secondary effluent was exceptionally low in the measured pollutants. Only minimal reduction in color was required to achieve BATEA effluent limits. It is believed that the main reason for this is that no desizing waste was being treated. Also, a major portion of the yarn used was dyed elsewhere. These factors tend to make Plant K production atypical of Subcategory IV. Multi-media filtration with pre-coagulation was the recommended AWT process.

SUBCATEGORY V (Knit Fabric Finishing)

Plant W - Plant W was notable in that the secondary wastewater treatment plant effluent was below the BATEA guideline limitation for COD but not for BOD_5 and TSS. Multi-media filtration was the recommended AWT process. The projected 30-day average effluent achieved all BATEA limits except TSS (by 1 mg/l or 0.15 kg/kkg).

Plant Q - Multi-media filtration followed by granular activated carbon was the recommended AWT process for Plant Q. This technology achieved all BATEA limits.

Plant E - The secondary treatment plant effluent was successfully treated to within BATEA limitations with multi-media filtration followed by granular activated carbon adsorption.

SUBCATEGORY VI (Carpet Mills)

Plant F - The AWT technology recommended for Plant F was coagulation/clarification followed by multi-media filtration. This process was successful in achieving all BATEA limits. The coagulant combination found to be most effective was 35 mg/l cationic polymer and 1 mg/l anionic polymer.

SUBCATEGORY VII (Stock & Yarn Dyeing and Finishing)

Plant S - Coagulation/clarification followed by multi-media filtration was the recommended AWT process at Plant S. Based on candidate period data it was noted that the recommended process provided equivalent treatment to multi-media filtration followed by granular activated carbon except for TSS removal.

It was observed that the granular activated carbon beds were acting as a secondary filter and not effectively adsorbing soluble organics. The recommendation was made (based on isolated portions of the screening data) that operating conditions other than those used during candidate experimentation should provide more effective treatment with the coagulation/clarification/filtration process. These recommendations involve a lower clarifier overflow rate and increased coagulant dosage.

Plant EE - The secondary wastewater treatment facility effluent was within all BATEA limits during the period of pilot plant operations. It should be noted that the production processes employed produced a significantly less contaminated waste stream than many other Subcategory VII plants. The mill was involved in bleaching operations and no dyeing was being done at the time of pilot experimentation. A multi-media filter was recommended as an AWT process to account for certain seasonal increases in effluent TSS and COD.

7. Based on the results of the Analytical Quality Assurance Program (QA) it was observed that relative percent errors in the range of 31 percent for BOD_5 (± 6 mg/l at 20 mg/l), 20 percent for COD (± 40 mg/l at 200 mg/l), 32 percent for TSS (± 6 mg/l at 20 mg/l), 27 percent for chromium (± 0.14 mg/l at 0.5 mg/l), 43 percent for phenol (± 0.22 mg/l at 0.5 mg/l), and 68 percent for sulfide (± 0.68 mg/l at 1 mg/l) should be expected when measuring pollutants and pollutant properties at the low levels required by the BATEA guidelines.

   The results of the QA program indicated sufficient analytical quality to insure general validity of the data generated during this study.

   The procedures used during the QA program were reviewed and approved by the Process Measurement Branches of IERL - Research Triangle Park, NC and IERL - Cincinnati, OH prior to initiation of program activities.

CHAPTER III

PILOT TREATMENT UNIT DESCRIPTION

INTRODUCTION

Two identical mobile treatment units were constructed in order to evaluate selected advanced wastewater techniques as applied to textile wastewaters. The treatment techniques selected for evaluation included those technologies identified in the EPA textile guidelines proposed in July 1974, and others jointly selected by representatives of the textile industry and EPA. Those technologies include chemical coagulation/clarification, multimedia filtration, carbon adsorption, ozonation and dissolved air flotation (DAF). The piping was arranged to allow a high degree of flexibility in selecting the sequence of unit operations. The specific sequences of unit operations are discussed in Chapter IV.

PHYSICAL DESCRIPTION

The mobile pilot plant equipment was housed in an 8-ft. X 40-ft. aluminium-walled trailer. The rear section of the trailer contained the major portion of the treatment equipment, with the front section housing the analytical equipment, the ozonation reactors and the ozone generator. For details of piping and equipment layout see Figures 2 and 3. The equipment used in support of the unit operations is described in the following subsections.

Reactor/Clarifier

The clarifier was a steel-walled circular vessel with a conical-shaped bottom. The clarifier was seven feet in diameter and had a side wall depth of 6.5 feet. The effective volume of the tank was 1,650 gallons with a surface area of 38.5 square feet. In addition to the clarifier unit, there were four polyethylene tanks used for storage and/or mixing of chemical agents employed in the coagulation/clarification process and other ancillary equipment including pumps and agitators. Sludge accumulated in the conical bottom of the clarifier was withdrawn through a timer-hydraulic arrangement. The frequency and duration of withdrawal was adjusted to take into account varying sludge densities and accumulation rates. The wasted sludge was collected in a sludge holding tank outside the trailer for observation and sampling prior to disposal. A sketch of the reactor/clarifier unit is shown in Figure 4.

Multi-Media Filters

There were two identical multi-media filters in each trailer. The filters were 63 inches in height with a diameter of 14 inches and one square foot of surface area. The filters contained 3 media: anthracite coal, sand and gravel. There were 12 inches of anthracite, 12 inches of sand and 16 inches of gravel in each filter. A sketch of the filter unit is presented in Figure 5. The filters were operated in a downflow mode. The filters were backwashed with water from a tank which was also used to backwash the carbon columns. This backwash tank had an effective working storage of 350 gallons. Each filter was also equipped for surface washing.

Carbon Columns

There were three identical carbon columns in each trailer. The carbon columns had an overall height of 7.75 feet and an inside diameter of 7.5 inches. The carbon columns and flanges were constructed of Schedule 80 PVC. Each carbon column contained 40 pounds of either Westvaco or ICI carbon depending on the results of isotherm testing. Sufficient volume was allowed for expansion of the carbon bed during backwashing. The carbon columns were operated in a series, downflow mode. There were provisions for sampling between the carbon columns. The carbon columns were also equipped for backwashing. A sketch of a carbon column unit is presented in Figure 6.

Ozonation

The ozonation unit consisted of three pieces of equipment, the ozone generator and two ozone contactors. The ozone generator was manufactured by PCI Ozone Corporation (Model C2P-30). The capacity of the ozone generator was 6 grams per hour from oxygen. Each trailer had one large and one small ozone contactor. The large ozone contactor was a Schedule 80 PVC column 77 inches high and 11.625 inches inside diameter. The fluid dimensions of the small column at overflow were 67 inches high and 3 inches diameter with a capacity of 2.05 gallons (9.0 liters). The diffusers in the bottom of the ozone contactors were 70 mesh stainless steel screens. The contactors were operated in either a batch or a continuous (flow-through) mode. The off-gases were sampled to determine concentration of ozone and therefore, permit calculations of ozone utilization. A sketch of the ozone contactor units is presented in Figure 7.

Dissolved Air Flotation

Dissolved air flotation (DAF) was only screened in the trailers, as it could only be operated in a very limited scale, batch mode. A sketch of the DAF unit is presented in Figure 8.

Analytical Equipment

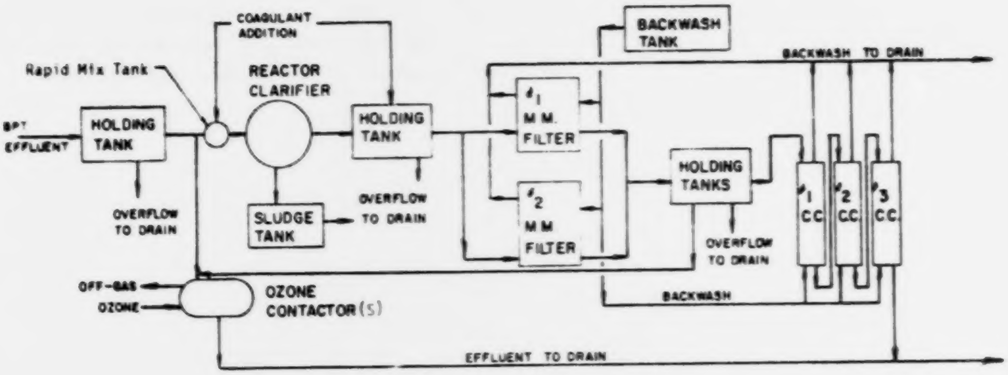
Analytical equipment in each trailer included a Photovolt Model 185 pH meter, a Coleman Model 295 spectrophotometer and an Ionics Model 1254 Total Carbon (TC) analyzer. Each of these instruments was used daily to provide information to make operational decisions and adjustments.

Ancillary Equipment

In addition to all other such equipment used directly with the pilot equipment, there was also complete jar testing equipment including a Phipps and Bird gang stirrer, glassware, reagents, flocculants, refrigerator, automatic composite samplers, wet sink, etc. The jar testing equipment was used in developing precise dosages of coagulants used in selected operational modes.

FIGURE 2

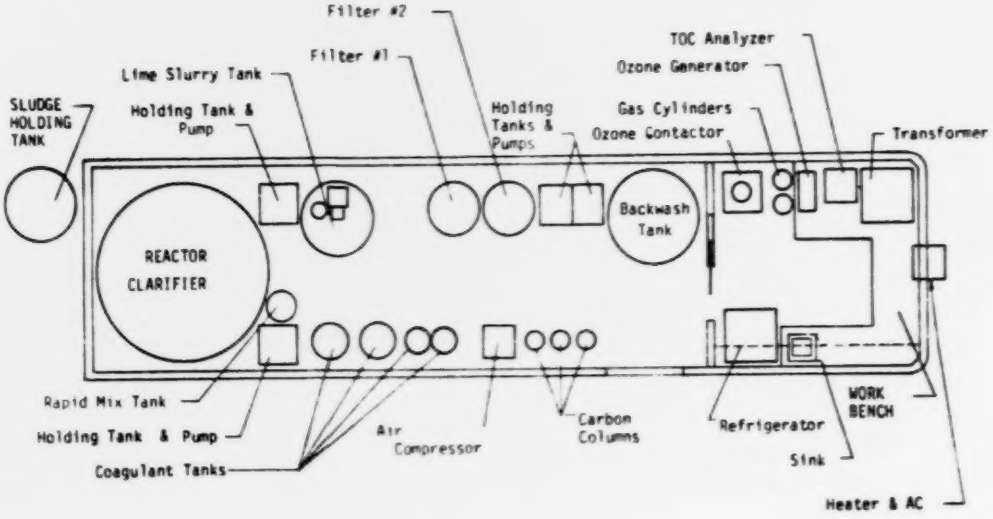
PILOT UNIT FLOW DIAGRAM


COAGULANT ADDITION
Rapid Mix Tank
REACTOR CLARIFIER
BPT EFFLUENT
HOLDING TANK
OVERFLOW TO DRAIN
SLUDGE TANK
HOLDING TANK
OVERFLOW TO DRAIN
BACKWASH TANK
BACKWASH TO DRAIN
#1 M.M. FILTER
#2 M.M. FILTER
HOLDING TANKS
OVERFLOW TO DRAIN
#1 C.C.
#2 C.C.
#3 C.C.
BACKWASH
OFF-GAS
OZONE
OZONE CONTACTOR(S)
EFFLUENT TO DRAIN

Legend: M.M. - Multi-Media
C.C. - Carbon Column

FIGURE 3

MOBILE PILOT PLANT PLAN VIEW


Filter #2
Filter #1
Lime Slurry Tank
SLUDGE HOLDING TANK
Holding Tank & Pump
Holding Tanks & Pumps
TOC Analyzer
Ozone Generator
Gas Cylinders
Ozone Contactor
Transformer
REACTOR CLARIFIER
Backwash Tank
Rapid Mix Tank
Holding Tank & Pump
Coagulant Tanks
Air Compressor
Carbon Columns
Refrigerator
Sink
WORK BENCH
Heater & AC

Not to Scale

FIGURE 4

SKETCH OF REACTOR/CLARIFIER

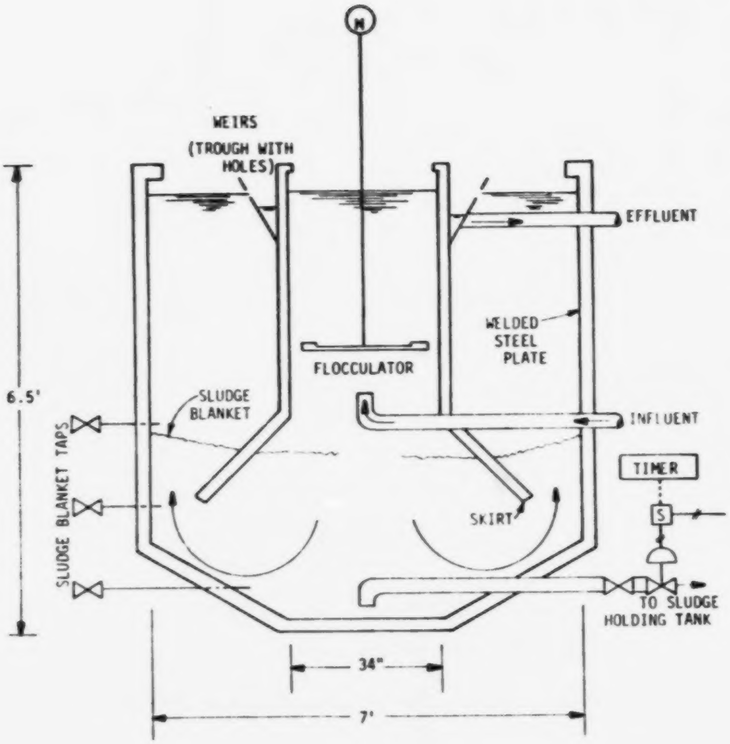
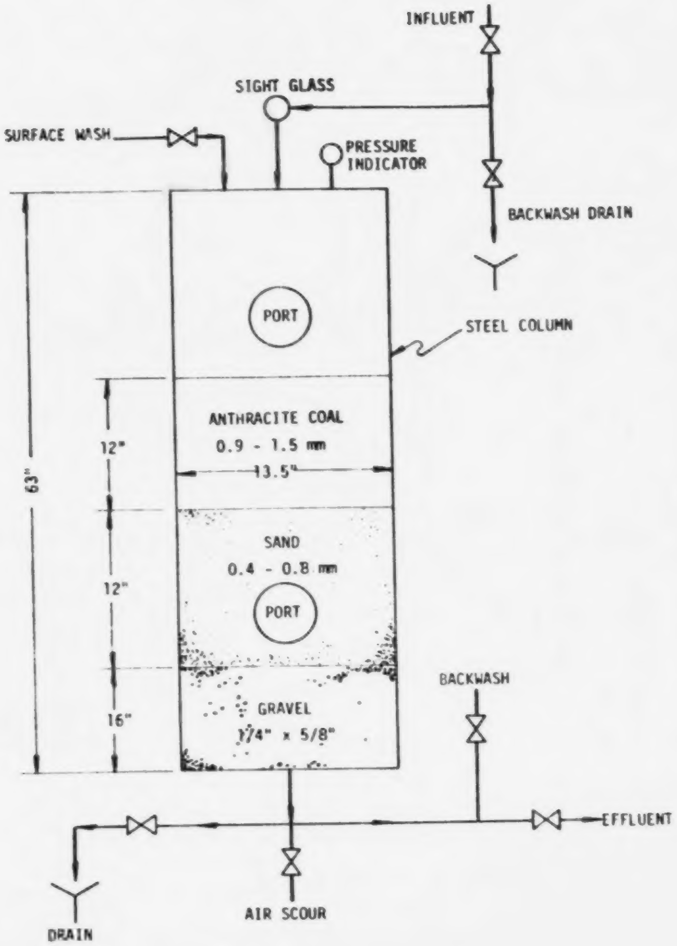

WEIRS
(TROUGH WITH
HOLES)
EFFLUENT
WELDED
STEEL
PLATE
FLOCCULATOR
6.5'
SLUDGE
BLANKET
INFLUENT
SLUDGE BLANKET TAPS
TIMER
S
SKIRT
TO SLUDGE
HOLDING TANK
34"
7'

FIGURE 5

SKETCH OF MULTI-MEDIA FILTER UNIT



INFLUENT
SIGHT GLASS
SURFACE WASH
PRESSURE INDICATOR
BACKWASH DRAIN
PORT
STEEL COLUMN
ANTHRACITE COAL
0.9 - 1.5 mm
13.5"
12"
63"
SAND
0.4 - 0.8 mm
12"
PORT
BACKWASH
16"
GRAVEL
1/4" x 5/8"
EFFLUENT
DRAIN
AIR SCOUR

FIGURE 6

SKETCH OF CARBON COLUMN UNIT

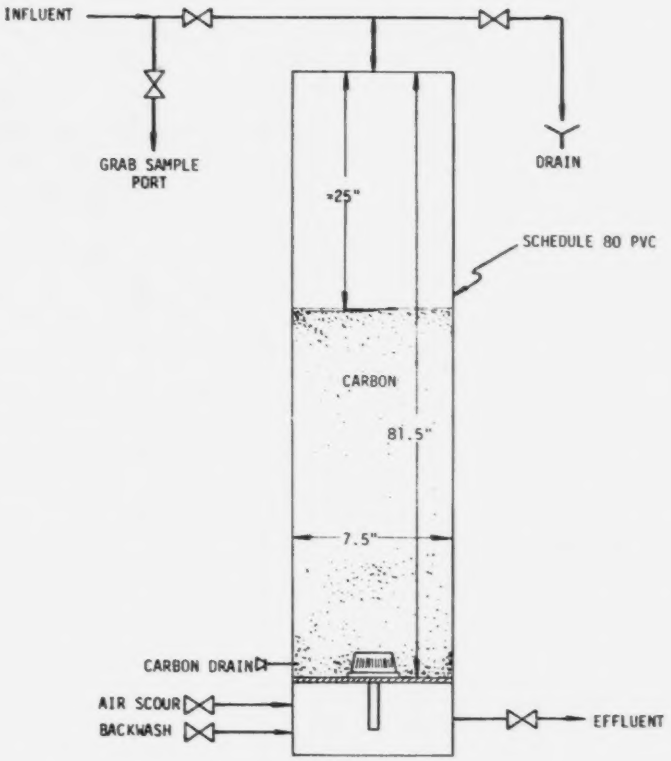

INFLUENT
GRAB SAMPLE PORT
DRAIN
≈25"
SCHEDULE 80 PVC
CARBON
81.5"
7.5"
CARBON DRAIN
AIR SCOUR
BACKWASH
EFFLUENT

FIGURE 7

SKETCH OF OZONE CONTACTORS

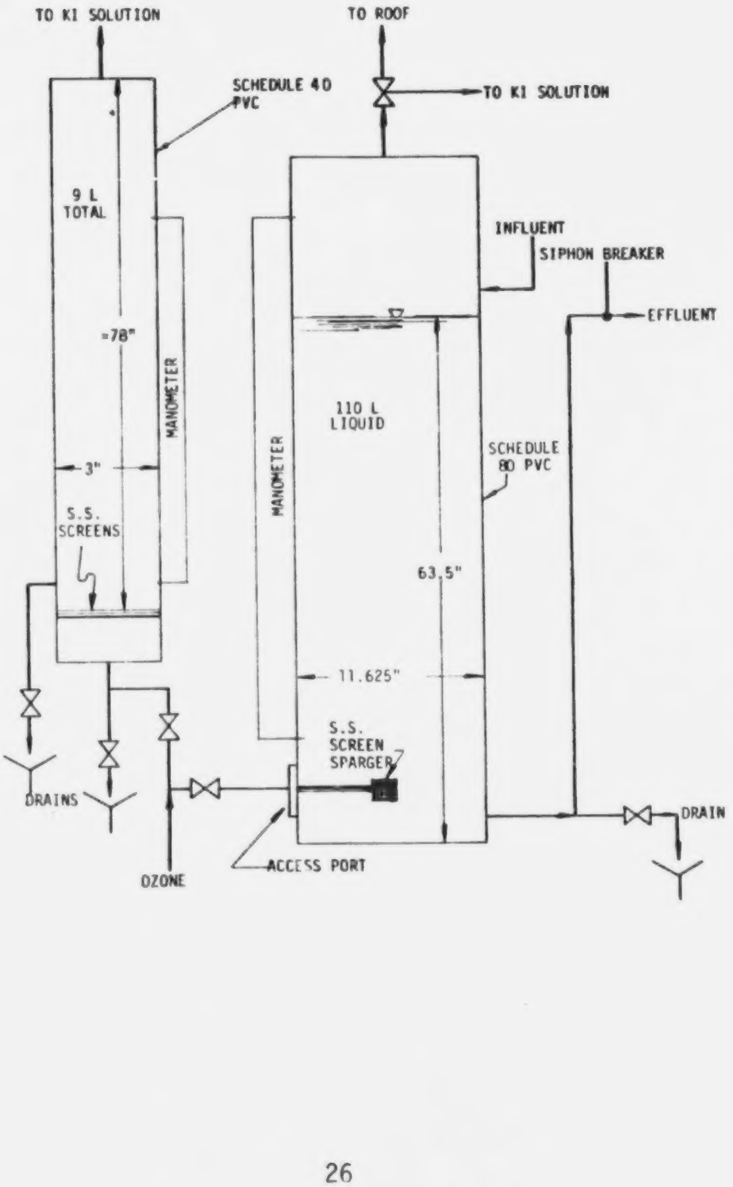
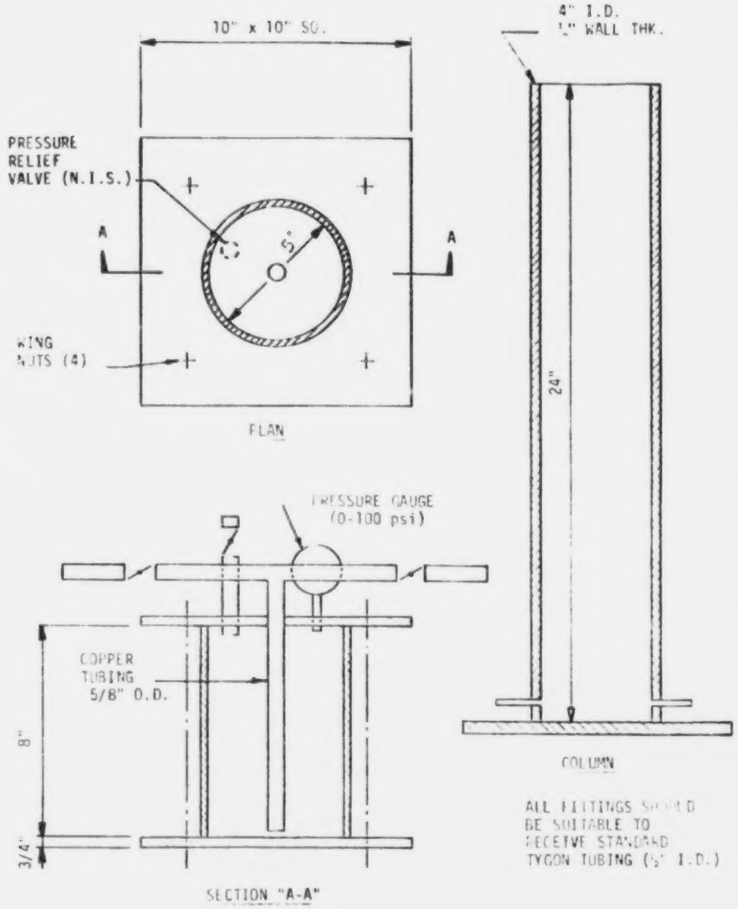

TO KI SOLUTION
TO ROOF
SCHEDULE 40 PVC
TO KI SOLUTION
9 L TOTAL
INFLUENT
SIPHON BREAKER
EFFLUENT
≈78"
MANOMETER
110 L LIQUID
SCHEDULE 80 PVC
3"
MANOMETER
S.S. SCREENS
63.5"
11.625"
S.S. SCREEN SPARGER
DRAINS
DRAIN
ACCESS PORT
OZONE

FIGURE 8

DAF UNIT


10" x 10" SQ.
PRESSURE RELIEF VALVE (N.I.S.)
A
A
5"
WING NUTS (4)
PLAN
PRESSURE GAUGE (0-100 psi)
COPPER TUBING 5/8" O.D.
8"
3/4"
SECTION "A-A"
4" I.D.
½" WALL THK.
24"
COLUMN
ALL FITTINGS SHOULD BE SUITABLE TO RECEIVE STANDARD TYGON TUBING (½" I.D.)

SCALE: 3" = 1'-0"

CHAPTER IV

PILOT STUDY EXPERIMENTAL PROGRAM

INTRODUCTION

The objective of the experimental program was to evaluate five potential BATEA process technologies (reactor clarifier, multi-media filtration, granular carbon adsorption, ozonation and dissolved air flotation) in order to determine which process technology(ies) or combinations of technologies will provide effective treatment of the existing wastewater treatment plant effluent. The experimental program was divided into two sections; screening of the process technologies and operation of the selected candidate process(es).

A general discussion of the experimental program is presented in this chapter. A detailed outline of the experimental program is included in Appendix B. A time-phase diagram of the experimental program is presented in Figure 9.

The pilot plant trailer was equipped with a pH meter, total carbon analyzer and spectrophotometer to assist the trailer engineer in making rapid evaluations of unit process performance. Samples were also sent to one or more of the six participating laboratories for more complete analyses. The sample locations are indicated in Figure 10 and the corresponding analytical schedule is presented in Table 6.

SCREENING

Prior to initiating the pilot plant study, it was necessary to select operating conditions and combinations of process technologies that had the greatest potential of success based on engineering judgment. With the schedule limitations of the project, it was not feasible to test all possible process trains or modifications of the BATEA technologies. The modes selected by ATMI, EPA and ES for experimental testing were as follows:

Mode A - Reactor/clarifier followed by multi-media filtration

Mode B - Multi-media filtration followed by granular carbon adsorption

Mode C - Multi-media filtration followed by ozonation

Mode D - Ozonation

Mode E - Reactor/clarifier followed by multi-media filtration followed by granular carbon adsorption followed by ozonation

Mode F - Multi-media filtration with precoagulation

TABLE 6

ANALYTICAL SCHEDULE

MODE A

Location 1* - COD, BOD_5, TSS, Cr_T, Phenol, Sulfide
Location 2 - COD, BOD_5, TSS, Cr_T
Location 3 - COD, BOD_5, TSS, Cr_T
Location 4 - TS, TSS

MODE B

Location 1* - COD, BOD_5, TSS, Cr_T, Phenol, Sulfide, COD_S
Location 2 - COD, BOD_5, TSS, Cr_T, COD_S, Phenol, Sulfide
Location 5 - COD, BOD_5, TSS, Cr_T, COD_S, Phenol, Sulfide

MODE C

Location 1* - COD, BOD_5, TSS, Cr_T, Phenol, Sulfide
Location 2 - Same as MB2, this is a split stream from the second filter
Location 3 - COD, BOD_5, Cr_T, Phenol, Sulfide, TSS

MODE D

Location 1* - COD, BOD_5, TSS, Cr_T, Phenol, Sulfide
Location 2 - COD, BOD_5, Cr_T, Phenol, Sulfide, TSS

MODE E

Location 1* - COD, BOD_5, TSS, Cr_T, Phenol, Sulfide, COD_S
Location 2 - COD, BOD_5, TSS, Cr_T
Location 3 - COD, BOD_5, TSS, Cr_T, COD_S
Location 6 - COD, BOD_5, Cr_T, Phenol, Sulfide, COD_S
Location 7 - COD, BOD_5, Cr_T, Phenol, Sulfide

MODE F

Location 1* - COD, BOD_5, TSS, Cr_T, Phenol, Sulfide
Location 2 - COD, BOD_5, TSS, Cr_T, Phenol, Sulfide

MODE G

Location 1* - COD, BOD_5, TSS, Cr_T, Phenol, Sulfide
Location 2 - COD, BOD_5, TSS, Cr_T, Phenol, Sulfide

* Location 1 Common to all trains, COD_S (Soluble COD) run only when carbon columns are in the process sequence.

Color, TOC and transmittance analyses are performed by ES at sample locations noted in Figure 10.

Mode G - Dissolved air flotation (bench-scale only)

The objective of the screening phase of the experimental program was to test Modes A, B, C, D, E, F and G in order to establish which technologies will operate effectively on the BPT effluent and to determine optimum operating conditions for the process(es). The screening phase of the program provided the information used to select the candidate mode(s) for performing additional testing during the final phase of the site visit.

Coagulant and Carbon Screening and Selection

Jar testing was conducted to identify the type of coagulant(s) and dosage(s) most effective for removal of suspended solids and organic material from the BPT discharge. This work was performed in the ES Atlanta Laboratory on waste shipped from the site prior to arrival of the trailer.

Coagulants evaluated included alum, ferric chloride, alum plus anionic polymers, ferric chloride plus anionic polymers, cationic polymers, cationic plus anionic polymers, lime, alum plus lime and ferric chloride plus lime. The test results were evaluated based on transmittance versus dosage plots, visual observation and sludge mass determination. A coagulant and optimum dosage was recommended to the trailer engineer for confirmation testing.

Carbon isotherm tests were performed on the BPT effluent using Westvaco and ICI carbon. The isotherm results were compared to select the carbon to be used in the carbon column tests.

Mode A - Reactor Clarifier and Multi-Media Filter

The purpose of this experiment was to evaluate removal of organic material and suspended solids by chemical coagulation, gravity settling and filtration. Tests were conducted using the reactor clarifier and one of the filter units.

The recommended coagulant(s) and dosage(s) were rechecked in the field to confirm the previous results and modifications were made as required. The reactor clarifier was initially operated at 400 gpd/ft^2 with BPT effluent and allowed to reach steady state. The influent, effluent and sludge were sampled to evaluate the performance. The loading was increased or decreased in increments of 200 gpd/ft^2 to establish the optimum loading.

The multi-media filter operated on the effluent of the reactor clarifier. The filter was initially loaded at 3 gpm/ft^2 for three backwash cycles to reach steady state. The filter was backwashed based on transmittance or solids breakthrough ($\geq$ 50% of influent transmittance in the effluent) or a maximum of 12 hours. Influent and effluent samples were collected for analyses and pressure differential, run time, backwash rate and backwash duration were recorded. The filter loading was increased to 5 gpm/ft^2 and then 7 gpm/ft^2 to evaluate performance at these higher loadings.

Mode B - Multi-Media Filter and Carbon Columns

The purpose of this experiment was to evaluate removal of suspended solids by filtration followed by removal of organic material by carbon adsorption. The multi-media filter was operated in the same manner as described in Mode A except the influent was BPT effluent. Once the highest acceptable loading was established, then the filter was operated at that loading for the remainder of the carbon run.

The effluent of the filter was further treated in the carbon columns. The columns operated on the filter effluent at a total empty-bed hydraulic retention time of 45 minutes. The first carbon column was backwashed daily and the other two columns were backwashed at least twice per week. Grab samples were collected from each column and composite samples of the influent and effluent were collected to evaluate the unit performance. The carbon columns were usually operated until the carbon in the first column had been exhausted.

Mode C - Multi-Media Filter and Ozonation

The purpose of this experiment was to evaluate removal of suspended solids by filtration and oxidation of organic material with ozone. Ozonation testing for screening was performed in batch tests on a split stream of the filter effluent from Mode B.

The ozone contactor was charged with wastewater and an ozone application rate was selected such that the total mass of ozone applied during the test was equal to 12 mg of ozone per mg of COD originally present in the column. Periodic samples of the off-gas were collected in gas wash bottles containing KI solution in order to determine ozone utilization by mass balance. Grab samples of the wastewater were removed from the contactor at 20-minute intervals for TOC and color analyses. The initial influent and final effluent were analyzed for all test parameters. The effectiveness and optimum ozone dosages were evaluated based on ozone utilized versus TOC and color removal.

Mode D - Ozonation

The purpose of this experiment was to evaluate direct oxidation of organic materials in the waste with ozone without pretreatment of the waste. Ozonation testing was performed with the same procedure as in Mode C except it was performed directly on the BPT effluent.

Mode F - Precoagulation and Multi-Media Filtration

The purpose of this experiment was to evaluate removal of suspended solids and organic materials from the waste by filtration after prefilter coagulation. The coagulant combination and dosage were established from the earlier jar tests. Additional jar testing was conducted to establish the dosage for pin floc formation. The coagulant was mixed with the BPT effluent and fed to the filter at a loading rate of 3 gpm/ft^2. The filter operation was performed the same as described in Mode B. An optimum loading was determined based on organic and suspended solids removal.

Mode G - Dissolved Air Flotation

The purpose of this experiment was to compare the effectiveness of dissolved air flotation (DAF) for removal of suspended solids with gravity settling. This experiment was performed with a batch DAF unit on the BPT effluent. The same coagulants and dosages used in Mode F were utilized for this experiment. The unit was operated at recycle rates of 100 percent, 50 percent and 33 percent. The influent and effluent were analyzed as indicated in Table 6 to evaluate the unit performance.

CONTINUOUS OPERATION OF SELECTED CANDIDATE PROCESS(ES)

At the completion of the screening period a joint decision was made by ES, EPA and ATMI as to which are the most effective processes for treating the BPT waste. The unit process operating conditions were also established at this point. The selected candidate process(es) were operated during the remainder of the site visit to encompass a variety of influent (BPT effluent) conditions so that the treatment efficiency could be monitored as a function of BPT effluent quality. The duration of these experiments depended on the unit processes involved and was calculated according to the statistical program presented in Appendix A.

If one of the candidate modes tested during the continuous phase of operations included granular carbon adsorption then the columns were recharged with virgin carbon at the start of the experiment. In some cases, the flow rate was increased to assure exhaustion of the first column at the end of the continuous mode test period.

When ozonation was tested as a candidate mode, then the experiment was conducted through continuous operation, when possible, instead of batch testing.

The results from the continuous operation of the candidate processes were evaluated to determine the effectiveness for treating the BPT effluent and to establish a recommended BATEA process specific to the individual plant site.

FIGURE 9

EXPERIMENTAL PROGRAM TIME-PHASE DIAGRAM

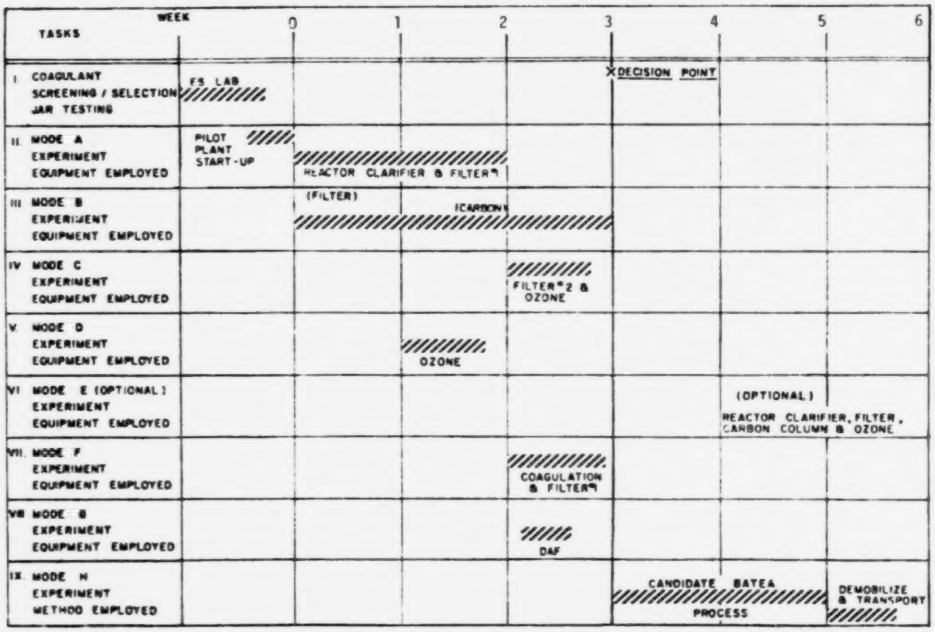
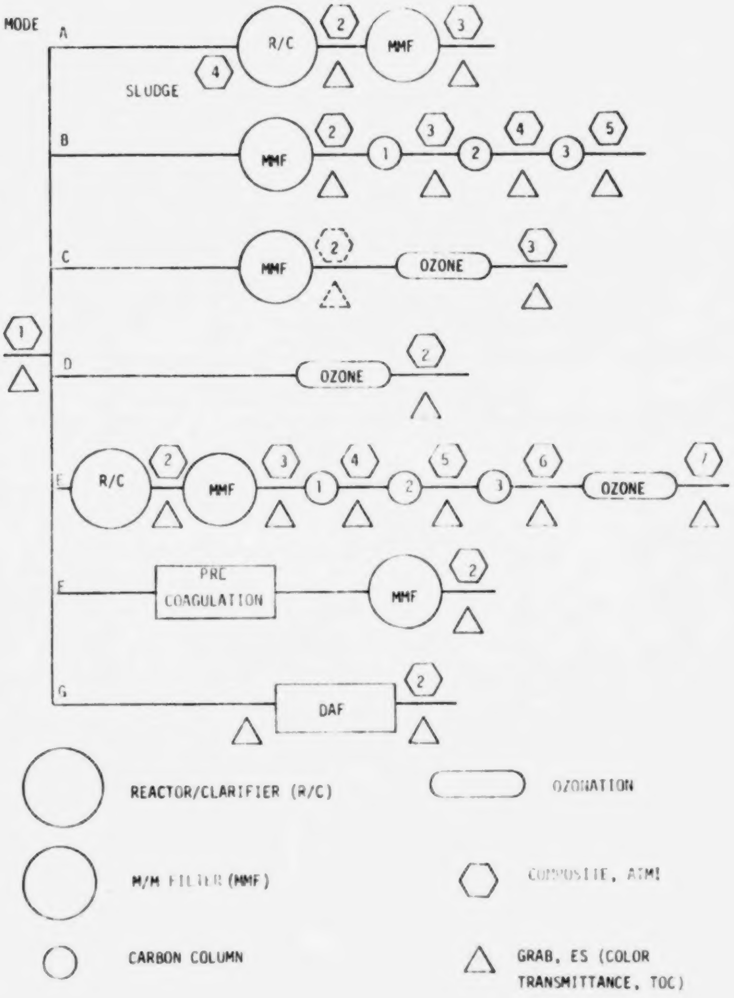


FIGURE 10

SAMPLE LOCATIONS


MODE
A
R/C
2
MMF
3
SLUDGE
4
B
MMF
2
1
3
2
4
3
5
C
MMF
2
OZONE
3
1
D
OZONE
2
E
R/C
2
MMF
3
1
4
2
5
3
6
OZONE
7
F
PRE COAGULATION
MMF
2
G
DAF
2
REACTOR/CLARIFIER (R/C)
OZONATION
M/M FILTER (MMF)
COMPOSITE, ATMI
CARBON COLUMN
GRAB, ES (COLOR TRANSMITTANCE, TOC)

CHAPTER V

TEST PLANT RESULTS

INTRODUCTION

The results from the experimental pilot program are presented and discussed in the following sections of this chapter. A summary is presented first, followed by a discussion of existing treatment facility performances and finally a presentation of the results of testing candidate processes at all 19 plants. More complete information on the individual plant studies can be found in the plant reports or in selected sections of the plant reports presented in Appendix C.

At each plant site screening tests were performed to determine the effectivemess of various modes of advanced waste treatment (AWT). As described in Chapter IV, AWT processes which indicated some effectiveness in the screening tests were selected as candidate modes of operation. These candidate modes were then operated on a continuous basis for a minimum of two weeks to obtain a data base assumed to be representative of actual candidate AWT operation. Candidate AWT performance, relative cost effectiveness and ability to meet the 1974 BATEA guidelines were taken into consideration; and a candidate mode was selected as the recommended AWT process. The selection procedure is described in more detail in Chapter VI, "Recommended Process Design".

SUMMARY OF TEST RESULTS

Shown in Table 7 is a matrix representation of the processes tested at each of the 19 plants. The recommended process as determined by this study is circled for each plant. The EPA recommended process as specified in the Development Document (EPA-4401-74-022a) is shown with a box. Also presented in the table is a qualitative comparison of the plant performance during the testing period with the BPT guideline requirements. The individual BPT guideline parameters not met are listed. In addition to this, BATEA treatment objectives (those parameters requiring reduction to achieve guidelines) are listed by plant site. Application of the recommended AWT process allowed 10 of the 19 plants tested to achieve the 1974 BATEA effluent guidelines limitations. The last column reports the plant's ability to achieve the guidelines using the recommended AWT processes. The parameters not meeting the 1974 BATEA limits are reported for those plants not achieving the limitations.

TABLE 7

SUMMARY OF PILOT PLANT TEST RESULTS

SUB-CATEGORY	PLANT	BPT †† GUIDELINES		AWT PROCESSES													BATEA * TREATMENT OBJECTIVES	ABILITY TO ACHIEVE BATEA W/ RECOMMENDED PROCESS (EXCEPTIONS) †
				1 R/C	2 MMF	3 MMF W/PRECOAG.	4 R/C MMF	5 MMF + O_3	5A MMF W/PRECOAG. + O_3	6 R/C O_3	7 R/C MMF O_3	8 MMF CC	8A MMF W/PRECOAG. CC	9 R/C MMF CC	10 MMF CC O_3	11 R/C MMF CC O_3		
		MET	NOT MET															
I	A	YES		●			▣				●			◉			1	YES
II	O	NO	SUL	●	●		▣	●				◉					5	NO (SUL)
	B	NO	BOD, TSS, COD	●			◙							●			2	YES (BOD/1)
III	NO SITES TESTED																	
IV	D	NO	COD, TSS		●		□					●			◉		3	NO (BOD, COD, COLOR)
	P	YES			◉	●	□						●				4	YES (TSS/3)
	V	NO	COD, TSS, BOD	●			▣					●		◉			5	NO (COD, TSS)
	Y	NO	TSS, COD		●		□					◉					2	YES
	Z	YES			●	●	□		●			◉					6	NO (COD)
	AA	NO	BOD, TSS				□		●				◉				6	NO (COD)
	BB	YES		●	●		▣					◉					3	NO (TSS, COD)
	DD	YES			●	◉	□					●					1	NO (TSS)
	T	YES			●		□					◉					1	NO (COD, TSS)
	K	YES				◉	□	●				●					8	YES
V	W	YES			◉	●	□					●					7	YES (TSS/1)
	Q	NO	COD	●	●	●	▣	●				◉					5	YES
	E	YES		●	●		▣					◉					5	YES
VI	F	YES		●			◙					·		●			3	YES
VII	S	NO	BOD	●	●		◙					●					5	NO (COD, TSS)
	EE	YES		●	◉		▣	●				●					8	YES

LEGEND:

- ● AWT PROCESS TESTED
- ○ RECOMMENDED PROCESS FROM ATMI STUDY
- □ RECOMMENDED PROCESS FROM EPA GUIDELINES ISSUED IN 1974

R/C - REACTOR/CLARIFIER
MMF - MULTI-MEDIA FILTER
MMF W/PRECOAG - MULTI-MEDIA FILTER WITH PRECOAGULATION
O_3 - OZONE
CC - CARBON

* PARAMETER CODES

1. TSS, COD
2. BOD, COD, TSS, CHR. & COLOR
3. COD, TSS, COLOR
4. TSS
5. BOD, COD, TSS
6. BOD, COD, TSS, COLOR
7. BOD, TSS
8. ALL PARAMETERS MET

† (EXCEPTION PARAMETER/mg/1 OVER BATEA VALUE)

†† BASED ON DURATION OF PILOT PLANT OPERATIONS. BOTH TEXTILE DATA AND SUPPORT LAB DATA CONSIDERED.

EXISTING TREATMENT FACILITIES PERFORMANCE

Textile mill production and existing BPT plant characteristics varied with each mill, as illustrated by the information presented in Tables 8 and 9.

Influent and effluent BOD, COD and TSS values for the existing BPT facility, monitored during the testing period, are presented in Table 10. BPT guideline values based on plant production during the same period were calculated and are shown on the same figure. BPT removal efficiencies were developed and are also listed. The ratio of the average BPT effluent values to the BPT guideline values is defined as the BPT performance ratio. This ratio is shown in the table for each plant. When the performance ratio is greater than one (1) for a particular parameter, the process performance did not achieve the guideline values for that parameter. Conversely when this ratio is less than one (1) the guideline values were achieved. The performance ratios and removal efficiencies for BOD, COD and TSS from this table are graphically illustrated on the bar charts in Figures 30, 31 and 32, respectively.

INDIVIDUAL PLANT TEST RESULTS

Test results from the continuous operation of candidate AWT processes are presented in the remainder of this chapter. A tabular comparison of treatment effectiveness for the candidate processes tested at each plant is presented in Tables 11 through 29. The reduction of pollutants with the AWT technologies tested is illustrated graphically in Figures 11 through 29. These tables and figures present the data categorized according to the candidate processes tested. For each candidate process the data includes the average, 90th percentile and 99th percentile confidence level effluent concentrations, and percent removal for BOD, COD, TSS, TOC, Phenol, Sulfide, Chromium, Color and Oil and Grease (statistical methods are described in Appendix A). The bar graph provided in each of these figures illustrates average percentage removal versus parameter and process for the candidate processes tested at each plant.

BATEA guideline values were calculated using production and flow data recorded during the testing period. BATEA performance ratios were developed using the 90th percentile confidence level effluent concentrations for the recommended AWT processes and the BATEA guideline values. These ratios are presented in the data matrix in Table 30. Similar to the BPT performance ratios, if the recommended process(es) did not achieve the BATEA guideline values, the BATEA performance ratios are greater than one and again, conversely, if the guideline values were achieved then the performance ratio is less than one.

The next series of figures (30 through 37) are graphical representations by parameter of removal efficiencies and performance ratios. The first in this series, Figure 30, shows the BOD removal efficiencies and per-

TABLE 8

SUMMARY OF PLANT PRODUCTION CHARACTERISTICS DURING TESTING PERIOD

SUBCATEGORY	PLANT CODE	TYPE PROCESSING		DESIZING				SCOURING	BLEACHING	MERCERIZING	DYEING	PRINTING	FINISHING	PRODUCTION LBS/DAY	PERCENT OF PRODUCTION CAPACITY	WATER USE GALS/LB
		SIMPLE	COMPLEX	STARCH	PVA	CMC	PAA									
I	A							X	(CARDING AND COMBING)					68,975	92%	3.3
II	O							X			X		X	28,127	80%	34.6
	B							(MANUFACTURING AND FINISHING WOOL AND BLENDED COTTON-VINYL-WOOL)						67,262	90%	14.6
IV	D	X	X		X				X		X		X	70,335	56%	5.8
	P		X	X	X	X		X	X	X	X		X	168,095	84%	11.7
	V	X	X	X	X	X			X	X	X		X	209,593	89%	14.6
	Y		X		X	X		X	X	X	X		X	72,846	50%	29.1
	Z		X	(YES)				X	X	X	X	X	X	389,425	102%	8.73
	AA		X		X			X	X	X	X		X	188,458	97%	12.8
	BB	COMMISSION			X		X	X	X		X		X	44,665	69%	12.9
	DD	X	X	X				X	X	X	X			179,898	79%	30.0
	T		X	X	X			X	X	X	X	X		651,738	87%	13.4
	K		X								X		X	34,363	80%	2.0
V	W		X					X	X		X	X	X	51,818	86%	18.2
	Q		X					X			X		X	157,040	75%	15.6
	E		X					X			X			56,874	65%	12.7
VI	F							WEAVING			X	X	X	329,903	72%	4.3
VII	S								X	X	X			50,809	62%	24.4
	EE			DESIZING				X	X		X			94,933	81%	10.2

TABLE 9

SUMMARY OF BPT WASTEWATER TREATMENT PLANT CHARACTERISTICS DURING TESTING PERIOD(1)

SUBCATEGORY	PLANT CODE	PRIMARY TREATMENT			AERATION BASIN				SECONDARY CLARIFIER OVERFLOW RATE gpd/sf	SLUDGE WASTING FACILITIES	% DESIGN FLOW	BPT GUIDELINES(3)		AVG. PLANT FLOW MGD
		EQUALIZATION	NEUTRALIZATION	SCREENING	dt hrs	SLUDGE AGE DAYS	HP/MG	MLSS LEVEL mg/l				MET	EXCEPTIONS	
I	A				160	200	160	27,000	210	X	55	YES		0.26
II	O		X	X	42	116	80	5,100	300	X	72	NO	SUL	0.72
	B	X		X	29	65	133	6,800	390	X	32	NO	BOD,COD, TSS	0.98
IV	D		X	X	140	61	125	3,700	145(2)		27	NO	COD, TSS	0.41
	P	X	X	X	168	1430	57	3,300	300	X	47	YES		2.0
	V		X	X	78	50	41	1,500	250		77	NO	COD, BOD, TSS	3.06
	Y	X	X	X	119	N.M.	57	N.M.	375	X	61	NO	TSS,COD	2.12
	Z			X	141	236	45	1,900	300	X	76	YES		3.40
	AA	X	X	X	72	131	66.7	3,900	425		69	NO	BOD, TSS	2.41
	BB	X			228	N.M.	15.8	N.M.	NA		123	YES		0.58
	DD		X	X	53	N.M.	87.5	N.M.	425	X	90	YES		5.40
	T	X		X	41	17	120	4,800	275	X	73	YES		8.72
	K			X	847	N.M.	37.5	N.M.	35	X	9	YES		0.17
V	W	X		X	69	66	37	2,000	565	X	100	YES		0.94
	Q	X		X	32	29	148	5,900	250	X	50	NO	COD	2.46
	E			X	101	246	80	2,600	310	X	71	YES		0.714
VI	F	X		X	169	52	37.5	400	250	X	114	YES		1.42
VII	S	X			75	147	46	350	320		83	NO	BOD	1.24
	EE	X	X	X	84	224	107	2,600	180	X	66	YES		0.86

1) BPT PLANT CHARACTERISTICS ARE BASED ON PERFORMANCE WHILE PILOT PLANT ON SITE
2) TWO UNITS IN SERIES
3) BASED ON PERFORMANCE DURING TESTING PERIOD WITH ACTUAL PRODUCTION VALUES AND PROJECT DATA

TABLE 10

BPT PERFORMANCE RATIOS AND REMOVAL EFFICIENCIES

FOR BOD, COD AND TSS

	SUBCATEGORY	I	II		IV										V			VI	VII	
PARAMETERS⁺	PLANT	A	O	B	D	P	V*	Y	Z	AA	BB	DD	T	K	W	Q	E	F	S	EE
BOD	INFLUENT mg/l	◤1249	340	317	269	331	301	N/A	531	438	361	238	1158	8	175	225	546	N/A	110	316
	EFFLUENT mg/l	72	8	212	18	13	21	10	23	42	16	10	19	15	4	8	19	43	30	5
	BPT GUIDELINE VALUE	194	30	92	68	33	28	13	46	29	62	13.4	29.6	79.7	16.8	18.7	23.8	217	17	45
	REMOVAL EFFICIENCY %	94	98	33	93	96	97	-	96	90	96	96	98	NEG	98	96	97	-	73	98
	BPT PERFORMANCE RATIO	.37	.27	2.3	.26	.39	.75	.77	.50	1.45	.26	.75	.64	.19	.24	.42	.80	.20	1.76	.11
COD	INFLUENT mg/l	◤8480	692	N/A	1514	N/A	1143	N/A	1691	1132	N/A	N/A	2050	111	386	939	906	N/A	392	761
	EFFLUENT mg/l	1079	180	1147	686	93	529	123	487	352	382	79	534	70	73	286	251	454	103	131
	BPT GUIDELINE VALUE	2534	236	671	670	518	493	229	800	504	557	208	535	1198	231	231	283	1956	208	582
	REMOVAL EFFICIENCY %	87	74	-	55	-	62	-	71	69	-	-	74	37	81	70	72	-	74	73
	BPT PERFORMANCE RATIO	.43	.76	1.71	1.02	.18	1.07	.54	.61	.70	.69	.38	1.00	.06	.32	1.2	.89	.23	.50	.23
TSS	INFLUENT mg/l	◤3129	58	166	82	79.3	N/A	N/A	221	80.3	67.5	53	120	21	N/A	40	N/A	N/A	39.8	26.2
	EFFLUENT mg/l	268	39	302	215	29	.89	38	55	99	49	16	22	10	28	65	61	93	41	11
	BPT GUIDELINE VALUE	592	50	145	183	90	73	36	122	88	165	36	79.8	216	72	84	103	306	43	117
	REMOVAL EFFICIENCY %	87	33	NEG	NEG	63	-	-	75	NEG	27	70	82	52	-	NEG	-	-	NEG	58
	BPT PERFORMANCE RATIO	.68	.78	2.08	1.17	.32	2.59	1.06	.45	1.13	.30	.44	.28	.05	.39	.78	.59	.30	.95	.09

N/A = Not Available ◤ Indicates Values From Monthly Averages

+ Influent average is Based on Data Supplied by the Textile Mills, Effluent Average is Based on Study Support Laboratory Data

* Pilot Plant not Run Continuously During Visit. Information Presented Here Is Based on Data Reported by Textile Plants.

TABLE 11

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT A

100% Subcategory I

TECHNOLOGY TESTED / PARAMETER	R/C* MMF CC		R/C MMF		R/C MMF O_3		R/C					
	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED
BOD	13	81	29	57	46	44	45	34				
COD	432	59	807	23	790	28	906	13				
TSS	31	91	102	69	103	72	185	43				
TOC	190	46	271	24	300	17	314	12				
PHENOL												
SULFIDE												
CHROMIUM												
COLOR	272	61	626	9	362	54	683	1				
OIL & GREASE	4	78	9	50	-	-	18	0				

TECHNOLOGY TESTED / PARAMETER	R/C* MMF CC		R/C MMF		R/C MMF O_3		R/C					
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	15	16	33	36	51	58	50	53				
COD	472	497	824	835	831	892	934	953				
TSS	40	46	116	124	129	167	204	217				
TOC	200	207	279	284	335	388	329	338				
PHENOL												
SULFIDE												
CHROMIUM												
COLOR	319	352	637	644	429	528	727	757				
OIL & GREASE	5.6	7.3	15	21			23	28				

* RECOMMENDED PROCESS

Reproduced from best available copy.

TABLE 12

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT O

66% Subcategory II
34% Subcategory VII

TECHNOLOGY TESTED / PARAMETER	MMF* CC		MMF		R/C		R/C MMF		MMF O_3			
	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED
BOD	2	71	3	57	2	67	2	67	13	0		
COD	18	90	112	35	111	35	84	51	35	72		
TSS	3	93	7	84	31	30	7	88	1	97		
TOC	7	79	33	3	30	9	27	18	25	17		
PHENOL	0.02	67	0.04	33	0.04	33	0.03	50	.02	67		
SULFIDE	.04	43	0.5	29	0.4	43	0.3	57	.85	23		
CHROMIUM	<.03	79	0.1	0	0.10	0	BDL	-	.13	13		
COLOR	30	83	97	44	108	38	65	62	-	-		
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	MMF CC		MMF		R/C		R/C MMF		MMF O_3			
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	2.3	2.4	3.0	3.2	2.6	2.7	2.1	2.2				
COD	23	26	122	127	121	128	89	93				
TSS	3.5	3.9	8.4	9.3	39	44	10	12				
TOC	7.5	8.0	34	35	30	31	27	28				
PHENOL	.025	.026	.042	.044	.04	.05	.035	.037				
SULFIDE	.415	.454	.59	.63	.50	.53	.36	.40				
CHROMIUM	.03	.03	.13	.14	.11	.12	.08	.08				
COLOR	36	39	99	100	138	156	73	78				
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 13

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT B

70% Subcategory II

TECHNOLOGY TESTED / PARAMETER	R/C & MMF *		R/C		R/C & MMF & CC							
	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED
BOD	31	85	39	81	16	92						
COD	174	85	190	83	26	98						
TSS	2	99	6	98	1	99						
TOC	61	84	68	83	15	96						
PHENOL	BDL	-	BDL	-	BDL	-						
SULFIDE	-	-	-		0.11	52						
CHROMIUM	0.049	80	0.053	78	0.086	67						
COLOR	-	-	-	-	-	-						
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	R/C & MMF		R/C		R/C & MMF & CC							
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	32	33	47	53	23	29						
COD	219	255	236	270	39	51						
TSS	3.9	5.4	9.7	12.7	1.6	2.1						
TOC												
PHENOL												
SULFIDE					.13	.15						
CHROMIUM	.062	.074	.066	.076								
COLOR	83	97	86	100	20	24						
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 14

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT D

100% Subcategory IV

TECHNOLOGY TESTED / PARAMETER	MMF * CC O_3		MMF		MMF CC							
	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED
BOD	47	NEG	19	21	13	46						
COD	349	57	630	23	422	48						
TSS	16	95	85	71	23	92						
TOC	106	41	157	4	101	44						
PHENOL												
SULFIDE	<.22	21	<.1	64	<.22	21						
CHROMIUM												
COLOR	149	85	1070	NEG	825	18						
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	MMF * CC O_3		MMF		MMF CC							
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	52	55	23	26	16	17						
COD	398	430	700	747	474	508						
TSS	21	25	129	159	28	31						
TOC	121	132	176	188	120	133						
PHENOL												
SULFIDE	<.29	<.33	-	-	<.30	<.35						
CHROMIUM												
COLOR	330	376	-	-	930	1006						
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 15

COMPARISON OF TREATMENT EFFECTIVENESS OF

AWT TECHNOLOGIES TESTED AT PLANT P

94% Subcategory IV
6% Subcategory VII

TECHNOLOGY TESTED / PARAMETER	MMF *		MMF W/PRECOAG		MMF W/PRECOAG & CC							
	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED
BOD	11	20	9	18	8	27						
COD	64	23	98	20	93	24						
TSS	16	31	21	NEG	-	-						
TOC	32	0	23	NEG	12	40						
PHENOL												
SULFIDE												
CHROMIUM			.010	29	.006	57						
COLOR	122	4	141	NEG	56	59						
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	MMF*		MMF W/PRECOAG		MMF W/PRECOAG & CC*							
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	15	17	16	27	10	11						
COD	75	84	112	129	41	46						
TSS	18	20	35	52	16	20						
TOC												
PHENOL												
SULFIDE												
CHROMIUM												
COLOR	130	135	188	301	62	69						
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 16

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT V

100% Subcategory IV

TECHNOLOGY TESTED / PARAMETER	R/C & * MMF & CC		R/C & MMF		R/C		MMF & CC					
	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED
BOD	1.2	87	2.5	73	3.6	61	1.6	77				
COD	176	55	331	16	352	10	186	53				
TSS	20	57	20	57	51	NEG	3.2	94				
TOC	36	53	62	18	72	5	35	47				
PHENOL												
SULFIDE												
CHROMIUM												
COLOR	85	66	283	NEG	274	NEG						
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	R/C & * MMF & CC		R/C & MMF		R/C		MMF & CC					
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	1.3	1.4	3.1	3.5	4.5	5.2	2.0	2.4				
COD	204	223	346	356	369	380	231	283				
TSS	24	27	24	26	59	65	4.2	5.5				
TOC	41	44	66	68	76	79	45	58				
PHENOL												
SULFIDE												
CHROMIUM							<.030	<.030				
COLOR	95	102	310	330	302	322						
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 17

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT Y

93% Subcategory IV
7% Subcategory VII

TECHNOLOGY TESTED / PARAMETER	MMF* & CC		MMF									
	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED
BOD	6	90	8	20								
COD	33	76	90	35								
TSS	2	96	10	80								
TOC	4	76	14	18								
PHENOL												
SULFIDE												
CHROMIUM	<.016	11	<.016	11								
COLOR	52	70	171	1								
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	MMF* & CC		MMF									
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	7	7	8.8	9.3								
COD	38	41	96	100								
TSS	3	3	14	17								
TOC	4.8	5.3	14	14								
PHENOL												
SULFIDE												
CHROMIUM												
COLOR	64	72	195	211								
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 18

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT Z

100% Subcategory IV

TECHNOLOGY TESTED / PARAMETER	MMF & * CC		MMF & W/PRECOA. O_3		MMF W/PRECOA.		MMF					
	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED
BOD	12	45	18	18	17	23	17	23				
COD	346	30	414	16	438	11	461	7				
TSS	11	68			35	0	20	41				
TOC												
PHENOL												
SULFIDE												
CHROMIUM	.019	17	.026	-	.023	0	.019	17				
COLOR	155	38	119	53	289	0	236	6				
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	MMF & * CC		MMF & W/PRECOAG O_3		MMF W/PRECOAG		MMF					
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	14	15	20	21	20	21	19	19				
COD	367	380	441	456	462	477	484	498				
TSS	13.1	14.4			42	46	24	26				
TOC												
PHENOL												
SULFIDE												
OIL & GREASE												
CHROMIUM	24	26	33	37	29	32	23	25				
COLOR	175	188	138	150	309	322	259	273				

*** RECOMMENDED PROCESS**

TABLE 19

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT AA

74% Subcategory IV
26% Subcategory V

TECHNOLOGY TESTED / PARAMETER	MMF * W/PRECOAG & CC		MMF W/PRECOAG & O_3									
	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED
BOD	9	79	13	70								
COD	169	55	222	40								
TSS	13	84	12	86								
TOC												
PHENOL												
SULFIDE												
CHROMIUM												
COLOR	171	53	129	64								
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	MMF * W/PRECOAG & CC		MMF W/PRECOAG & O_3									
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	10	11	14	15								
COD	190	203	241	253								
TSS	15	17	14	15								
TOC												
PHENOL												
SULFIDE												
CHROMIUM												
COLOR	200	218	141	148								
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 20

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT BB

100% Subcategory IV

TECHNOLOGY TESTED / PARAMETER	MMF & * CC		R/C & MMF		MMF		R/C					
	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED
BOD	19	27	9	65	23	12	12	54				
COD	210	44	147	61	353	7	162	57				
TSS	28	44	38	24	40	20	60	0				
TOC												
PHENOL	0.053	56	0.054	55	0.08	33	0.065	46				
SULFIDE												
CHROMIUM	0.113	33	0.059	65	0.159	5	0.058	65				
COLOR	214	47	191	53	364	10	190	53				
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	MMF & * CC		R/C & MMF		MMF		R/C					
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	21	22	10	11	25	26	14	16				
COD	224	233	164	175	361	366	185	200				
TSS	31	34	53	63	46	50	97	121				
TOC	48	51	46	50	96	98	48	52				
PHENOL	.058	.062	.058	.060	.09	.09	.070	.073				
SULFIDE												
CHROMIUM	.126	.135	.071	.080	.17	.17	.072	.081				
COLOR	257	286	224	248	416	453	219	240				
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 21

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT DD

77% Subcategory IV
23% Subcategory II

TECHNOLOGY TESTED / PARAMETER	MMF W/ PRECOAG *		MMF & CC		MMF							
	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED
BOD	6	54	6	25	5	38						
COD	39	45	31	53	56	13						
TSS	6	45	6	35	7	29						
TOC	15	21	13	35	20	0						
PHENOL	BDL	-	BDL	-	BDL	-						
SULFIDE	BDL	-	BDL	-	BDL	-						
CHROMIUM	0.04	73	0.05	50	.110	0						
COLOR	126	36	-	-	-	-						
OIL & GREASE	-	-	-	-	-	-						

TECHNOLOGY TESTED / PARAMETER	MMF W/PRECOAG		MMF & CC		MMF							
EFFLUENT CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	8	9	11	13								
COD	46	48	54	64								
TSS	14	18	16	20								
TOC												
PHENOL												
SULFIDE												
CHROMIUM	.052	.056	.120	.148								
COLOR												
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 22

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT T

100% Subcategory IV

TECHNOLOGY TESTED / PARAMETER	MMF & CC *		MMF									
	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED
BOD	6	70	9	55								
COD	410	17	178	3								
TSS	16	24	17	19								
TOC	98	36	1443	5								
PHENOL	.024	40	.053	7								
SULFIDE	0.7	36	1.1	0								
CHROMIUM	BDL	-	BDL	-								
COLOR	56	73	206	0		-						
OIL & GREASE	-	-	-	-								

TECHNOLOGY TESTED / PARAMETER	MMF & CC *		MMF									
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	7.3	.1	10	11								
COD	474	515	537	576								
TSS	19	22	20	22								
TOC			159	170								
PHENOL	.029	.033	.065	.073								
SULFIDE	.90	1.03	1.43	1.63								
CHROMIUM												
COLOR	66	73	249	278								
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 23

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT K

100% Subcategory IV

TECHNOLOGY TESTED / PARAMETER	MMF * W/PRECOAT		MMF & CC		MMF		MMF & O_3					
	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED
BOD	6	58	9	37	14	7	14	6				
COD	41	46	21	71	65	14	52	35				
TSS	9	16	3	76	5	57	3	72				
TOC												
PHENOL												
SULFIDE												
CHROMIUM	.015	21	.014	26	.015	21	.012	14				
COLOR	136	65	55	86	384	3	154	59				
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	MMF * W/PRECOAT		MMF & CC		MMF		MMF & O_3					
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	8	9	10	11	15	16	17	19				
COD	45	48	24	25	67	69	56	60				
TSS	12	15	3.7	4.2	6.2	7.0	4.4	5.4				
TOC												
PHENOL												
SULFIDE												
CHROMIUM	.018	.020	.016	.018	.019	.022	.014	.016				
COLOR	181	215	65	72	399	410	209	250				
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 24

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT W

100% Subcategory V

TECHNOLOGY TESTED / PARAMETER	MMF*		MMF & CC		MMF W/PRECOAG							
	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED
BOD	3.4	26	1.5	67	2.6	43						
COD	55	25	19	74	48	34						
TSS	9.5	63	2	92	13	50						
TOC	11	21	2.9	79	10	29						
PHENOL												
SULFIDE												
CHROMIUM												
COLOR	118	16	29	79	83	41						
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	MMF *		MMF & CC		MMF W/PRECOAG							
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	4	4	2	2	3	4						
COD	58	60	21	22	51	53						
TSS	12	13	2	3	16	17						
TOC	12	13	4	6	12	13						
PHENOL												
SULFIDE												
CHROMIUM												
COLOR	136	149	35	39	97	106						
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 25

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT Q

100% Subcategory V

TECHNOLOGY TESTED / PARAMETER	MMF * & CC		MMF		R/C & MMF		MMF W/PRECOAG		R/C		MMF & O_3	
	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED
BOD	2	74	4.4	46	3.4	54	7.1	31	5.4	27	4.9	30
COD	58	79	208	24	179	30	258	24	195	23	17.8	93
TSS	2.5	96	4	91	24	52	28	64	73	0	3	93
TOC			22	19			18.3	0				
PHENOL												
SULFIDE												
CHROMIUM	.032	35	.051	14	.037	8	.070	7	.094	0	.048	0
COLOR	120	50	250	1	224	1	-	-	202	11	51	77
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	MMF * & CC		MMF		R/C & MMF		MMF W/PRECOAG		R/C		MMF & O_3	
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	2.2	2.4	4.9	5.4	4.2	7.6	8	8	6.1	6.8	8.1	9.8
COD	64	68	217	226	186	266	280	285	252	304	25	30
TSS	2.7	2.8	6.7	8.6	38	54	48	48	83	93	6	9
TOC			28	85								
PHENOL												
SULFIDE												
CHROMIUM	.060	.078	.059	.071	.069	.090	.080	.098	.115	.133	.080	.116
COLOR	133	151	363	804	260	305	-	-	218	233	-	-
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 26

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT E

100% Subcategory V

TECHNOLOGY TESTED / PARAMETER	MMF * & CC		MMF		R/C & MMF		R/C					
	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED
BOD	3.8	80	10.8	44	9.3	52	10.1	48				
COD	31.7	88	157	40	104	60	122	53				
TSS	2.3	96	4.3	92	3.7	93	13.1	76				
TOC	5.3	81	29	0	22.4	18	24	12				
PHENOL												
SULFIDE												
CHROMIUM												
COLOR	59.2	69	144	25	55	72	53	73				
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	MMF * & CC		MMF		R/C & MMF		R/C					
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	4	5	13	14	12	14	14	16				
COD	36	39	172	182	114	120	132	138				
TSS	3	4	6	7	5	6	18	21				
TOC	6	7	32	34	25	27	27	29				
PHENOL												
SULFIDE												
CHROMIUM												
COLOR	69	75	159	168	66	69	85	92				
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 27

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT F

100% Subcategory VI

TECHNOLOGY TESTED / PARAMETER	R/C * & MMF		R/C		R/C & MMF & CC							
	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED
BOD	7	85	7	85	6	87						
COD	120	74	142	69	45	90						
TSS	9	89	28	67	5	94						
TOC	25	73	26	72	5	95						
PHENOL	.04	69	.06	54	.02	85						
SULFIDE	-	-	-	-	-	-						
CHROMIUM	BDL	-	BDL	-	BDL	-						
COLOR	168	73	202	68	39	94						
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	R/C * & MMF		R/C		R/C & MMF & CC							
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	9	9	9	10	7	8						
COD	131	138	159	170	59	68						
TSS	12	14	34	38	8	10						
TOC	28	29	28	30	6	6						
PHENOL	.044	.046	.064	.067	-	-						
SULFIDE												
CHROMIUM												
COLOR	181	190	230	248	48	55						
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 28

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT S

100% Subcategory VII

TECHNOLOGY TESTED / PARAMETER	R/C * & MMF		R/C		MMF & CC		MMF					
	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED	EFF mg/1	% RED
BOD	6	81	6	81	6	82	7	79				
COD	67	20	83	1	72	23	106	0				
TSS	12	74	19	60	6	87	12	74				
TOC	6	50	7	42	5	50	8	20				
PHENOL												
SULFIDE												
CHROMIUM												
COLOR	106	58	104	59	112	54	235	2				
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	R/C * & MMF		R/C		MMF & CC		MMF					
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	7	8	7	8	7	8	8	8				
COD	86	99	103	118	88	99	120	128				
TSS	16	19	24	27	8	9	15	17				
TOC	7	7	8	8	5	6	9	10				
PHENOL												
SULFIDE												
CHROMIUM												
COLOR	119	130	117	128	124	132	268	291				
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 29

COMPARISON OF TREATMENT EFFECTIVENESS OF AWT TECHNOLOGIES TESTED AT PLANT EE

40% Subcategory IV
60% Subcategory VII

TECHNOLOGY TESTED / PARAMETER	MMF *		R/C & MMF		MMF & CC		MMF & O_3		R/C			
	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED	EFF mg/l	% RED
BOD	3	28	2	45	<2	45	6	0	<2	44		
COD	104	34	67	44	29	76	149	1	93	22		
TSS	15	78	7.6	51	4	72	7	74	26	0		
TOC	43	0	33	25	10	76	40	3	36	18		
PHENOL	BDL	-	BDL	-	BDL	-	BDL	-	-	-		
SULFIDE	.1	50	.1	50	BDL	-	.1	50	.13	32		
CHROMIUM	BDL	-	BDL	-	BDL	-	BDL	-	-	-		
COLOR	170	11	72	62	25	87	49	72	120	37		
OIL & GREASE												

TECHNOLOGY TESTED / PARAMETER	MMF *		R/C & MMF		MMF & CC		MMF & O_3		R/C			
EFFLUENT % CONFIDENCE LIMITS	90	99	90	99	90	99	90	99	90	99	90	99
BOD	3.1	3.6	-	-	<2	2	6.6	7.2	<2	<2		
COD	141	178	83	92	40	46	179	204	109	118		
TSS	18	21	11	14	6	6	11	14	33	37		
TOC									37	38		
PHENOL												
SULFIDE	.178	.215	.119	.126	.115	.119	.170	.199	.151	.164		
CHROMIUM												
COLOR	182	192	84	91	28	30	58	65	140	153		
OIL & GREASE												

* RECOMMENDED PROCESS

TABLE 30

BATEA PERFORMANCE RATIOS FOR RECOMMENDED AWT PROCESSES BY PARAMETER

	SUBCATEGORY	I	II		III	IV										V			VI	VII	
	PLANT	A	O	B		D	P	V	Y	Z	AA	BB	DD	T	K	W	Q	E	F	S	EE
PARAMETERS	RECOMMENDED AWT PROCESSES	R/C MMF CC	MMF CC	R/C MMF		MMF CC O_3	MMF	R/C MMF CC	MMF CC	MMF CC	MMF W/P.C. & CC	MMF CC	MMF W/PRE-COAG.	MMF CC	MMF W/PRE-COAG.	MMF	MMF CC	MMF CC	R/C MMF	R/C MMF	MMF
BOD	90th PERCENTILE AWT VALUE	15	2	39	NO SITES TESTED	51.4	15	1.3	7	14	14	21	8	7.3	8	4	2.2	4	8.5	7.3	3.1
	BATEA VALUE	88	13	38		45	22	18	9	30	19	41	8	20	54	11	13	16	56	11	30
	PERFORMANCE RATIO *	.17	.15	1.03		1.14	.68	.07	.78	.47	.74	.51	1.0	.37	.15	.36	.17	.25	.15	.66	.10
COD	90th PERCENTILE AWT VALUE	471	23	210		397	75	204	38	366	190	224	46	474	45	58	64	36	131	86	141
	BATEA VALUE	661	79	223		223	173	161	76	266	168	186	62	179	399	77	94	95	326	69	194
	PERFORMANCE RATIO *	.71	.29	.94		1.78	.43	1.27	.50	1.38	1.13	1.20	.74	2.64	.11	.75	.68	.38	.40	1.25	.73
TSS	90th PERCENTILE AWT VALUE	40	4	20		21	18	24	3	14	15	31	14	19.3	12	12	2.7	3	12	16	18
	BATEA VALUE	74	8	21		31	15	12	6	21	15	28	6	14	37	11	13	16	28	9	23
	PERFORMANCE RATIO *	.54	.50	.95		.68	1.2	2.0	.50	.67	1.00	1.11	2.33	1.37	.32	1.09	.21	.19	.43	1.78	.78
PHENOL	90th PERCENTILE AWT VALUE		.025					-	BDL	BDL		.058		0.029					.04		BDL
	BATEA VALUE		0.13	0.21		0.10	0.5	0.4	.21	.69	0.36	0.93		.45	1.21	0.33	0.38	0.47	0.56	0.29	0.74
	PERFORMANCE RATIO *		.19									.06		.06					.07		
SULFIDE	90th PERCENTILE AWT VALUE		.415			<.29			BDL	BDL				—							0.18
	BATEA VALUE		0.26	0.41		2.05	1.0	0.8	0.42	1.37	0.72	1.86			2.43	0.66	0.76	0.95		0.99	1.49
	PERFORMANCE RATIO *		1.60			1.14															.12
CHROMIUM	90th PERCENTILE AWT VALUE		.03	0.076					<.015	.024		0.126	.052		.018		0.06				BDL
	BATEA VALUE		0.13	0.21		0.10	0.5	0.4	0.21	0.69	0.36	0.93	.188	.45	1.21	0.33	0.38	0.47	0.56	0.29	0.74
	PERFORMANCE RATIO *		0.23	.36					.07	.03		.14	.28		.01		.16				
COLOR	90th PERCENTILE AWT VALUE	319	36	205		351	130	95	64	175	199	257		66.2	181	136	133	69	181	119	182
	BATEA VALUE	600	<500	<600		<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<225	<300	<300
	PERFORMANCE RATIO *	.53	0.07	.34		1.17	.43	.32	.21	.58	0.66	.86	0.42	.22	.60	.45	.44	0.23	.80	0.40	.61
OIL AND GREASE	90th PERCENTILE AWT VALUE	6																			
	BATEA VALUE	37																			
	PERFORMANCE RATIO *	.16																			

$$\text{*BATEA PERFORMANCE RATIO} = \frac{\text{RECOMMENDED AWT PERFORMANCE}}{\text{BATEA GUIDELINE VALUE}}$$

BDL - BELOW DETECTABLE LIMITS

formance ratios. Figure 31 shows COD; Figure 32 shows TSS, etc. Both the BATEA recommended AWT values and the BPT values are shown on the BOD, COD and TSS figures (30, 31 and 32). Because the remaining parameters were generally not a problem with BPT facility performance, only the BATEA values are shown for Phenol, Chromium, Sulfide, Color and Oil and Grease (Figures 33, 34, 35, 36 and 37).

Table 31 contains a comparison of the BPT and BATEA performance ratios for the plants tested. The BPT and corresponding BATEA performance ratios are listed for all parameters that did not achieve the guideline values. Of the 19 plants visited, 11 were able to achieve the BPT effluent guidelines with the existing secondary facilities. Of these plants, seven were able to meet BATEA limits with AWT, and four were not able to meet BATEA limits with AWT. Of the 19 plants visited, eight were not able to achieve the BPT effluent guidelines with the existing secondary facilities. Of these plants, three were able to meet BATEA limits with AWT and five were not able to meet BATEA limits with AWT. No definite trends were observed relating the ability of a secondary system to achieve or not achieve the BPT limits corresponding with AWT process ability to achieve or not achieve BATEA limits. However, more plants with secondary systems achieving the BPT limits were able to achieve the BATEA limits with the AWT technology than the number of plants with secondary systems that were not meeting BPT limitations.

Data presented in this final report has been condensed from the individual plant reports which were provided for use by the participating plants. The "Conclusions and Recommendations" and the "Introduction to Textile Mill Facilities" chapters from all 19 plant reports are included in Appendix C of this report.

AWT EFFECTIVENESS SUMMARY

Coagulation/clarification was a selected candidate process in Subcategories II, V, VI and VII. This technology was successful in reducing BOD by 27 to 85 percent (with an average of 58 percent), COD by 13 to 78 percent (with an average of 42 percent), TSS by 0 to 86 percent (with an average of 45 percent), and color by 11 to 68 percent (with an average of 46%). Coagulation/clarification was also able to reduce concentration of phenol and sulfide in certain instances when present in the waste stream. In Subcategories I and IV, coagulation/clarification was not found to be a viable treatment alternative. This was due primarily to the fact that effective coagulants were not found for use with the process at the plants in these subcategories.

Pilot experimentation showed that, in most cases, multi-media filtration was an effective process for TSS reduction. Removals of 19 to 92 per-

TABLE 31

COMPARISON OF BPT AND BATEA PERFORMANCE

Subcategory	Plant	Parameter	Performance Ratio	
			BPT	BATEA
I	A	All	< 1	< 1
II	O	All	< 1	< 1
	B	BOD	2.3	1.03
		COD	1.71	0.94
		TSS	2.08	0.95
IV	D	BOD	0.26	1.14
		COD	1.02	1.78
		TSS	1.17	0.68
		Color	-	1.17
	P	TSS	0.32	1.2
	V	COD	1.07	1.27
		TSS	2.59	2.00
	Y	TSS	1.06	0.50
	Z	COD	0.61	1.38
	AA	BOD	1.45	0.74
		COD	0.70	1.13
		TSS	1.13	1.00
	BB	COD	0.69	1.20
		TSS	0.30	1.11
	DD	TSS	0.44	2.33
	T	COD	1.00	2.64
		TSS	0.28	1.37
	K	All	< 1	< 1
V	W	TSS	0.39	1.09
	Q	COD	1.20	0.68
	E	All	< 1	< 1
VI	F	All	< 1	< 1
VII	S	BOD	1.76	0.66
		COD	0.50	1.25
		TSS	0.95	1.78
	EE	All	< 1	< 1

If a parameter was not listed for an individual plant, this indicates that both the BPT and BATEA performance ratios were less than one.

Performance ratio = effluent value/guideline value cent were noted (with an average of 59 percent). The relative success of the multi-media filtration process appears to be a function of TSS concentration and colloidal particle size distribution. It was noted that this process was generally more successful when influent TSS were less than 100 mg/l. It is believed that in some cases the colloidal particles in the filter influent were too small to be retained within the filter media. Multi-media filtration, through the removal of suspended material, was able to reduce significant amounts of BOD, total COD, and apparent (unfiltered) color. In the cases where coagulation/clarification was a viable treatment alternative, multi-media filtration was used successfully for the control of floc carryover.

Granular activated carbon adsorption was effective for soluble pollutant removal, usually following multi-media filtration. In general, COD reductions of 41 to 84 percent were realized but in certain instances where the organic compounds in the waste stream were relatively non-adsorbable, removals as low as 5 percent were noted. Granular carbon was usually effective in reducing BOD and quite successful in color reduction.

Ozone treatment of the textile waste stream usually followed multi-media filtration but was also applied directly to secondary effluent or following granular activated carbon in a few cases. In almost all cases, ozonation was ineffective in removing organic pollutants, and most COD removals measured were less than 20 percent. In only one case a high COD removal was noted (91 percent) and this required excessive dosages (1100-1500 mg O_3 utilized per liter). A BOD increase was often detected after ozonation of the waste stream. Ozone was, however, usually quite successful at reducing color in the waste stream. Color removals of 44 percent to 71 percent were measured after application of ozone.

SUBCATEGORY PERFORMANCE REVIEW

There was one (1) textile plant visited that was classified in Subcategory I (Wool Scouring). The candidate processes tested were additional clarification followed by multi-media filtration and additional clarification followed by multi-media filtration followed by either granular activated carbon adsorption or ozonation. The clarifier and filter removed BOD_5, TSS, and Oil and Grease well and COD to a lesser extent. Addition of ozonation to the treatment train significantly enhanced color removal but had the negative effect of increasing BOD concentration (over filter effluent). When carbon columns were used following the clarifier and filter, significant improvement was observed in the reduction of all measured pollutants. Additional clarification followed by multi-media filtration followed by granular activated carbon adsorption was the recommended process that successfully achieved the BATEA limits. The treatment effectiveness of the AWT technologies for this subcategory is summarized in Table 11.

There were two plants tested that were classified under Subcategory II (Wool Finishing). The six candidate processes at these two sites consisted of combinations of coagulation/clarification, multi-media filtration, granular activated carbon adsorption and ozonation. The two recommended processes were multi-media filtration followed by granular activated carbon adsorption (in the case where secondary effluent TSS were low) and coagulation/clarification followed by multi-media filtration (in the case where secondary effluent TSS were high). Both of the recommended processes were effective in removing significant amounts of all measured pollutants and all BATEA guidelines were achieved with the exception of sulfide at one of the two plants. AWT performance for Subcategory II can be examined in Tables 12 and 13.

More textile mills were selected from Subcategory IV (Woven Fabric Finishing) for experimentation during this study than any other single subcategory within the industry. This was done because there are more operating mills of this type than any other within the industry and the process variability within this subcategory generally tends to make wastewater treatment more difficult. A wide variety of AWT processes were tested at the Subcategory IV plants. The ones recommended in the majority of the cases (seven out of ten) were multi-media filtration followed by granular activated carbon adsorption (in some cases either preceded by coagulation/clarification or followed by ozonation). At seven of the ten plants tested in this subcategory, the selected AWT processes were unable to treat the waste stream to within the BATEA limits for COD and/or TSS. AWT treatment effectiveness can be reviewed in Tables 14 through 23.

Three textile mills from Subcategory V (Knit Fabric Finishing) were selected for AWT evaluation. The AWT technologies were tested in various combinations at these plants. In two cases, the recommended process was multi-media filtration followed by granular activated carbon adsorption and in the third case, the recommended process was multi-media filtration alone. These processes were successful in reducing waste stream pollutant levels to within the BATEA limits in all three cases. AWT treatment effectiveness for Subcategory V can be reviewed in Tables 24 through 26.

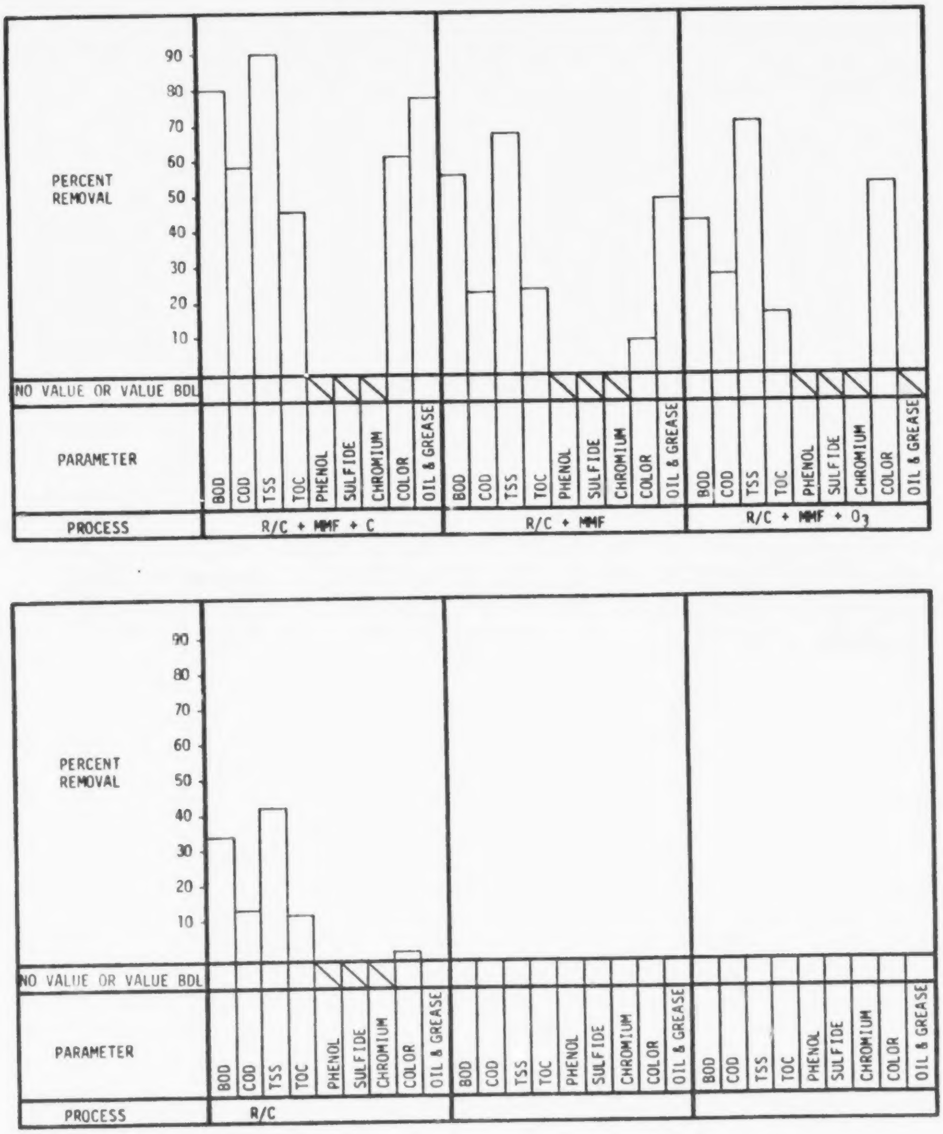
One Subcategory VI (Carpet Mills) plant was visited during this study. The candidate AWT systems evaluated at this plant were coagulation/clarification and coagulation/clarification followed by either multi-media filtration and granular activated carbon or multi-media filtration alone. The reactor/clarifier alone was able to remove 50 percent or more of all the measured pollutants except sulfide. The addition of multi-media filter to the process train significantly enhanced only TSS removal (increased by about 20 percent). The addition of granular activated carbon to the other processes increased removal of all measured pollutants, except for color by approximately 15 percent. Color reduction was enhanced by the addition of activated carbon by 20 to 25 percent. The recommended process for this plant was coagulation/clarification followed by multi-media filtration. Addition of granular activated carbon adsorption to the process train was not required to achieve the BATEA guideline limits. AWT effectiveness for Subcategory VI can be reviewed in Table 27.

Two Subcategory VII (Stock and Yarn Dyeing) plants were included in the study. At one site, the existing secondary treatment system was producing an effluent with pollutant levels within the BATEA limits. A multi-media filter alone was recommended to control wintertime increases in TSS discharge that had been experienced in the past. At the other site coagulation/clarification followed by multi-media filtration was recommended. This process performed comparably to multi-media filtration. The selected process was unable to produce an effluent within BATEA pollutant levels. AWT treatment effectiveness is given in Tables 28 and 29.

FIGURE 11

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT A

100% Subcategory 1

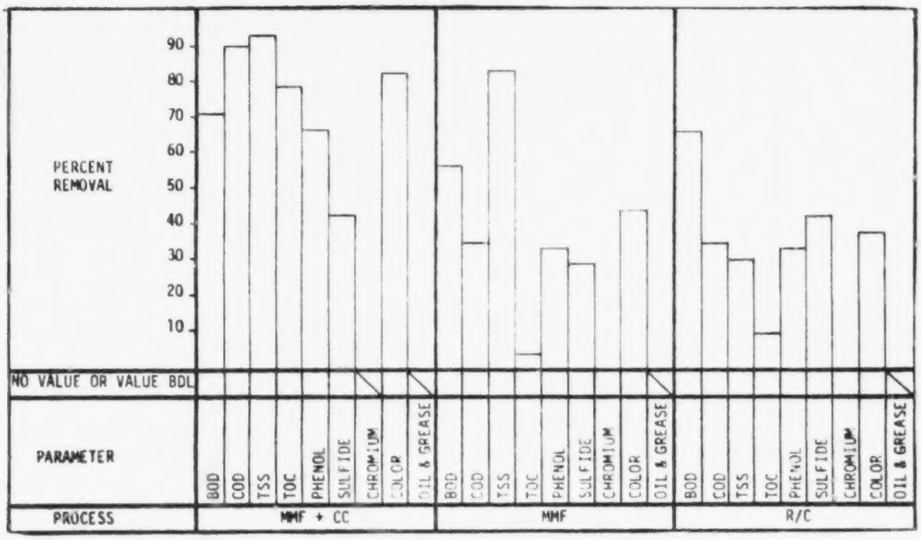


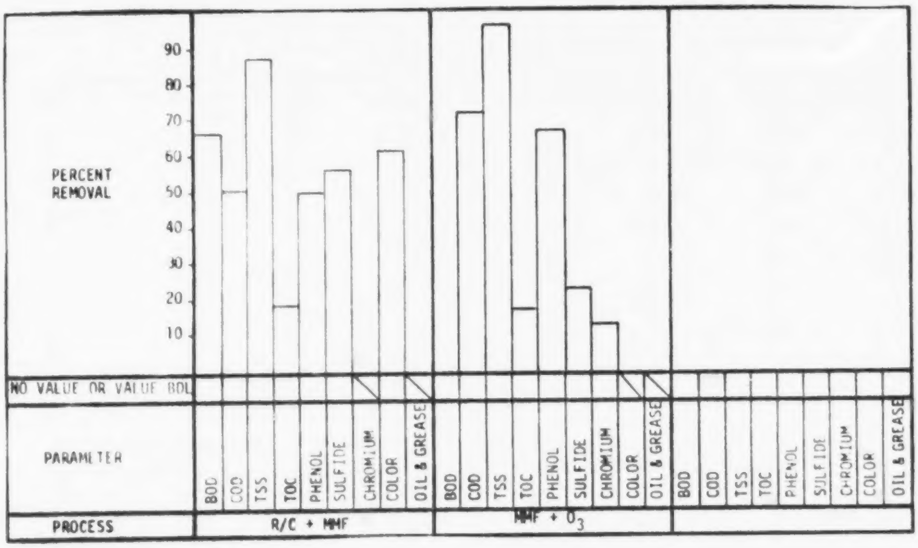
BDL - BELOW DETECTABLE LIMITS

FIGURE 12

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT O

66% Subcategory II
34% Subcategory VII





BDL - BELOW DETECTABLE LIMITS

FIGURE 13

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT B

70% Subcategory II

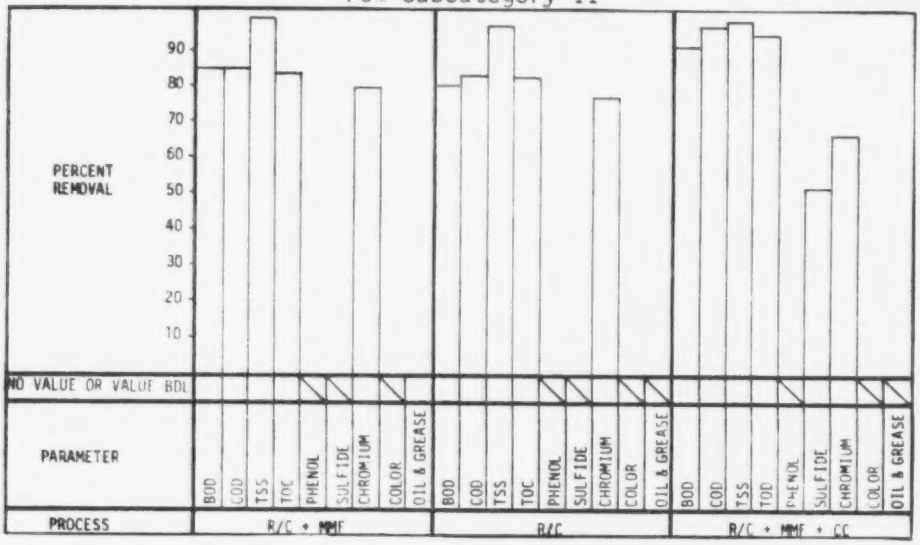
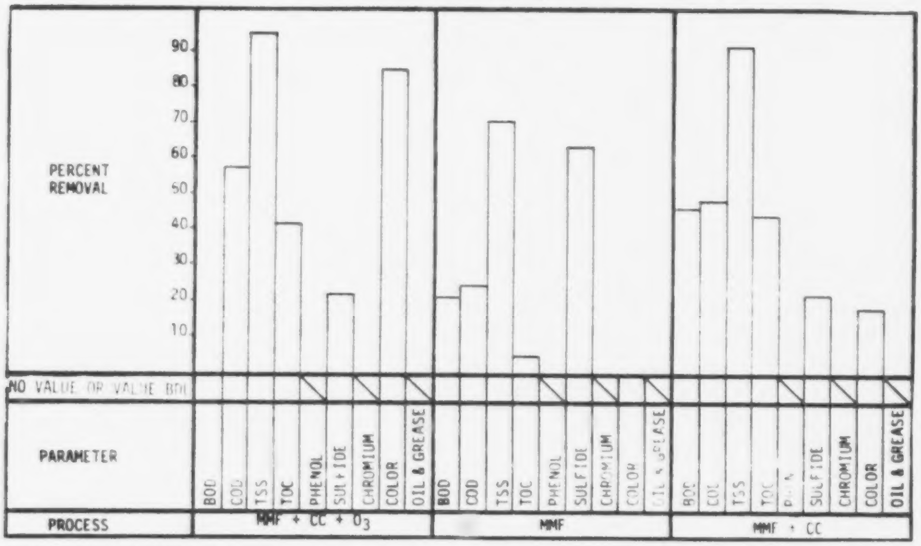


FIGURE 14

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT D

100% Subcategory IV

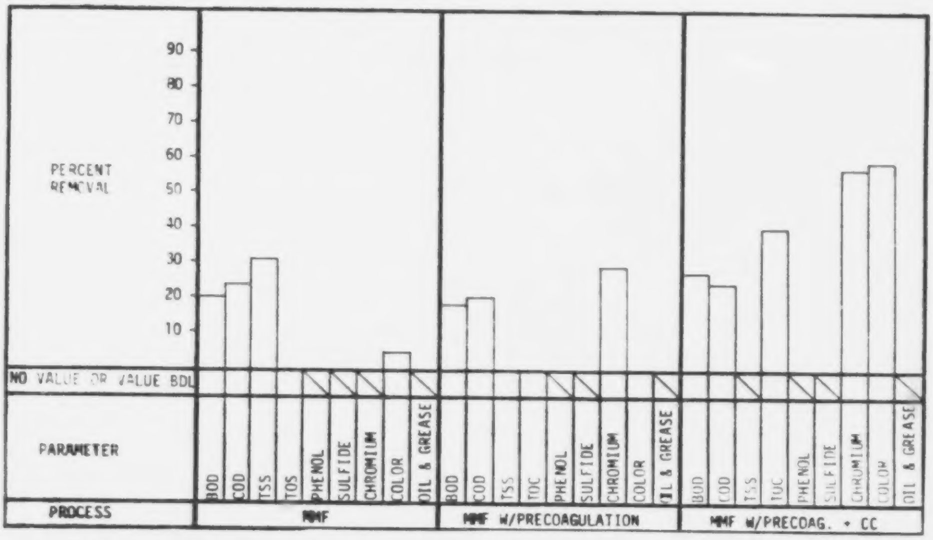


BDL - BELOW DETECTABLE LIMITS

FIGURE 15

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT P

94% Subcategory IV
6% Subcategory VII

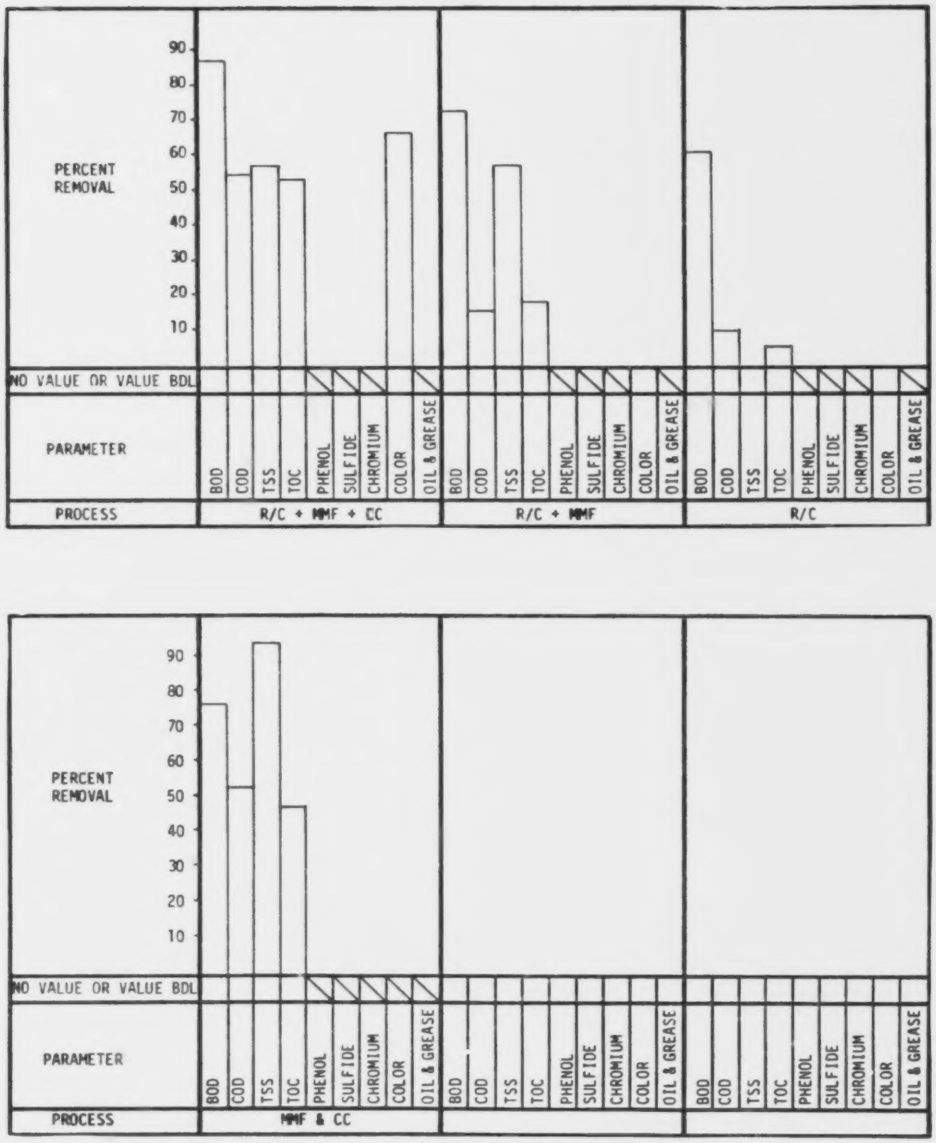


BDL - BELOW DETECTABLE LIMITS

FIGURE 16

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT V

100% Subcategory IV

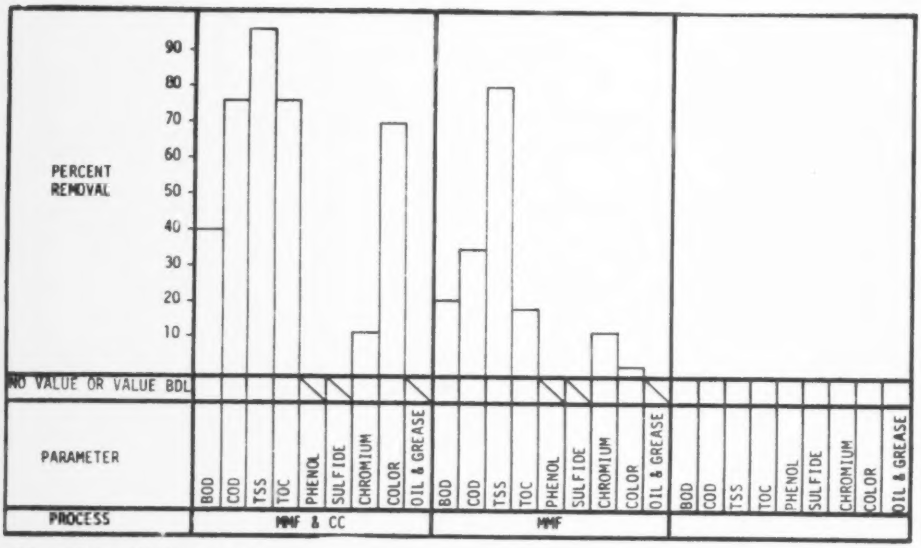


BDL - BELOW DETECTABLE LIMITS

FIGURE 17

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT Y

93% Subcategory IV
7% Subcategory VII

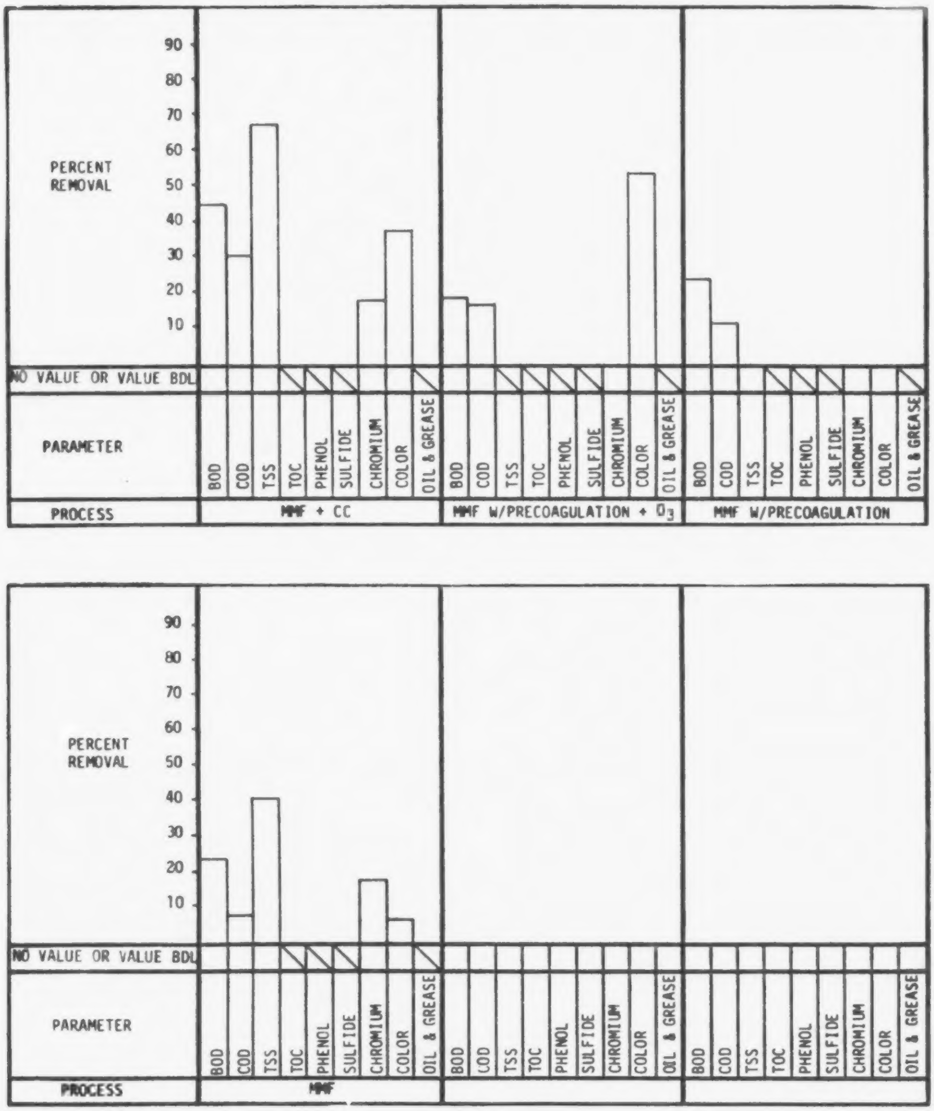


BDL - BELOW DETECTABLE LIMITS

FIGURE 18

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT Z

100% Subcategory IV

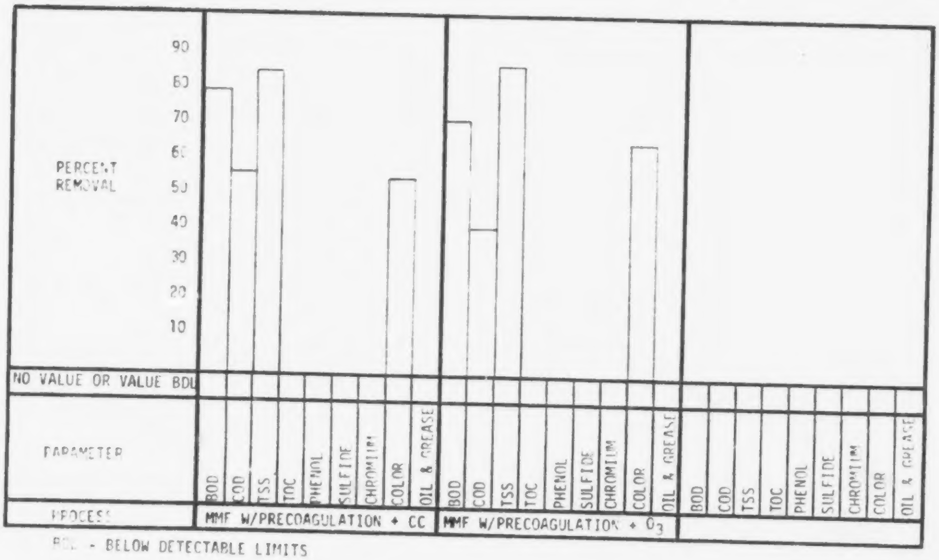


BDL - BELOW DETECTABLE LIMITS

FIGURE 19

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT AA

74% Subcategory IV
26% Subcategory V

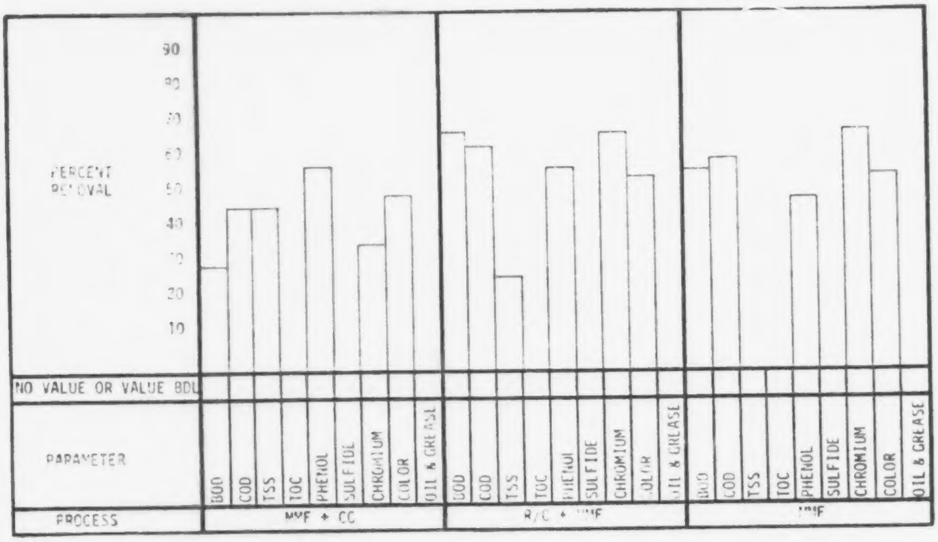


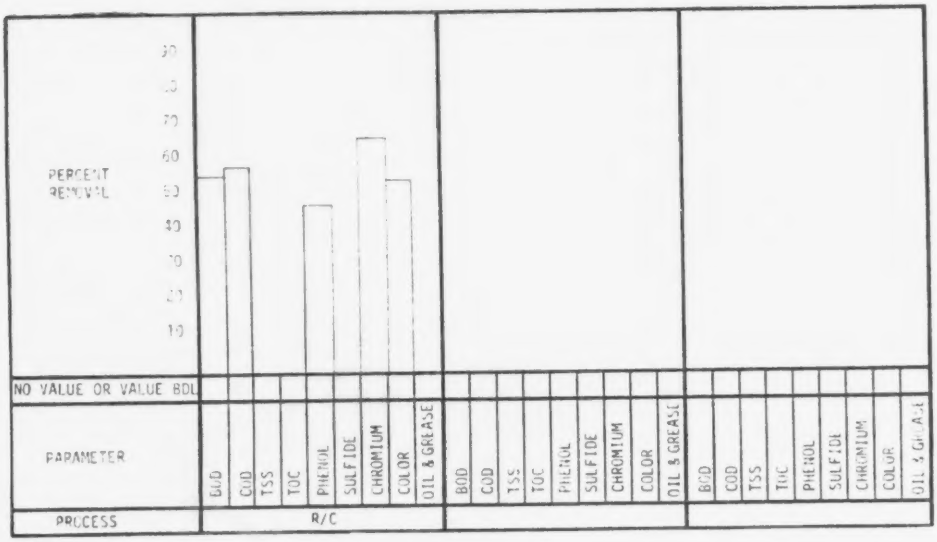
BDL - BELOW DETECTABLE LIMITS

FIGURE 20

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT BB

100% Subcategory IV





BDL - BELOW DETECTABLE LIMITS

FIGURE 21

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT DD

77% Subcategory IV
23% Subcategory II

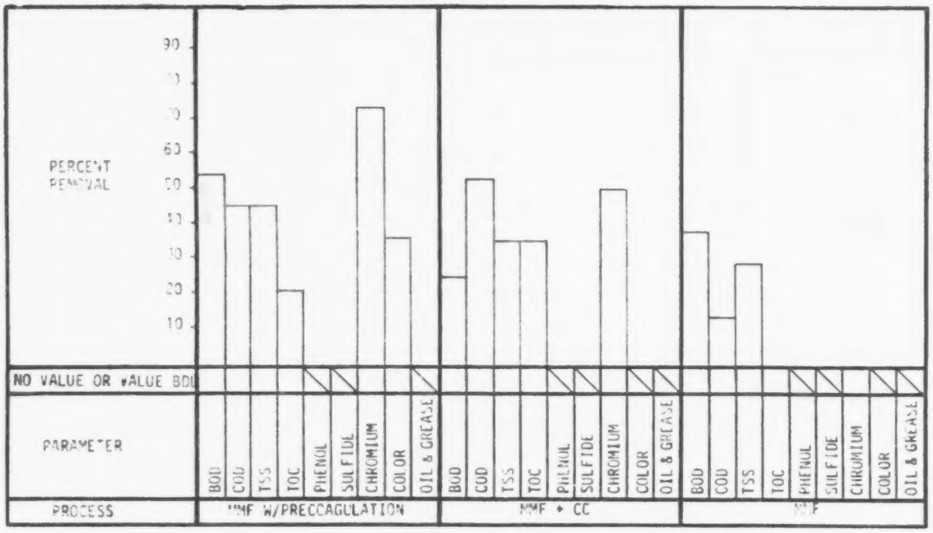
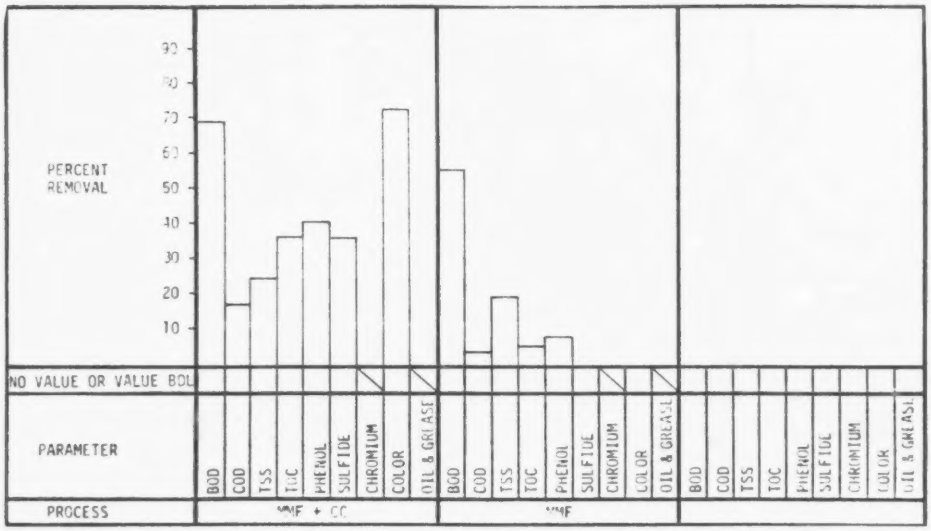


FIGURE 22

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT T

100% Subcategory IV

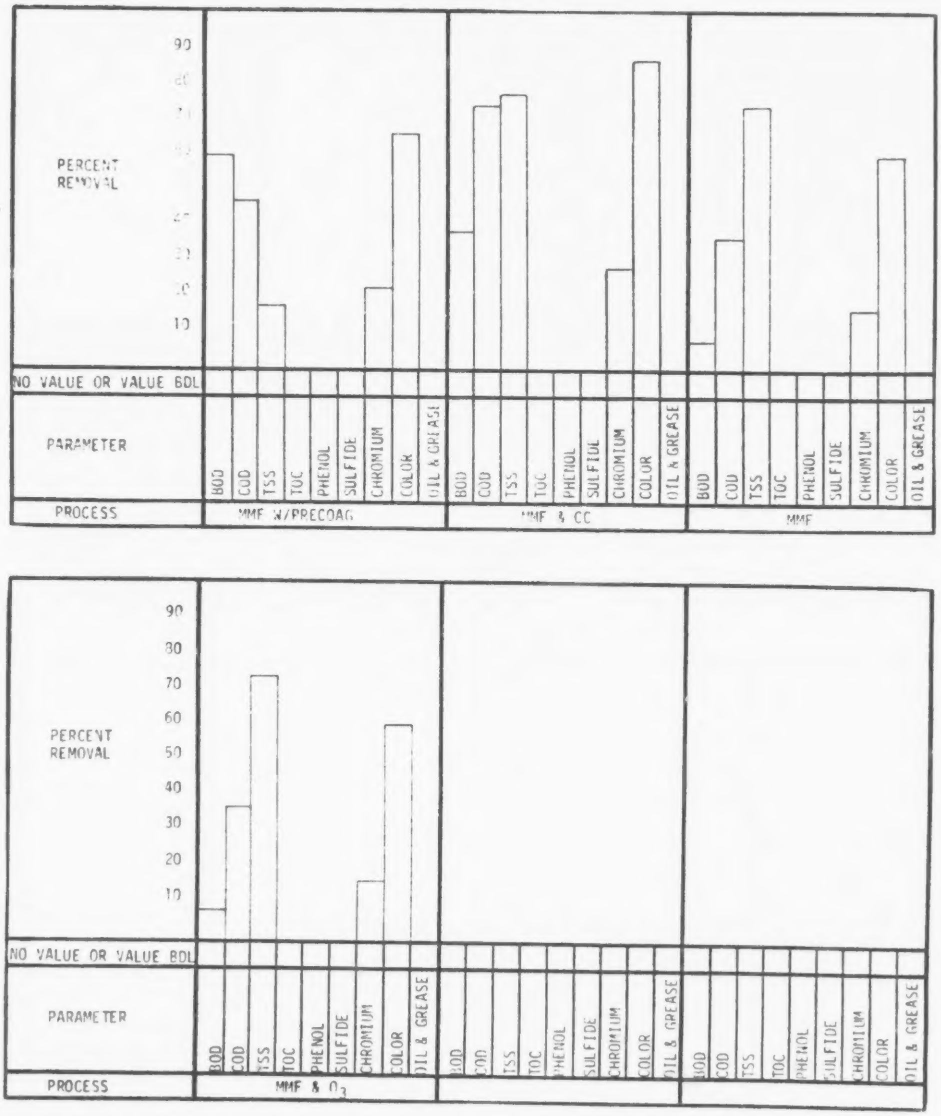


BDL - BELOW DETECTABLE LIMITS

FIGURE 23

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT K

100% Subcategory IV

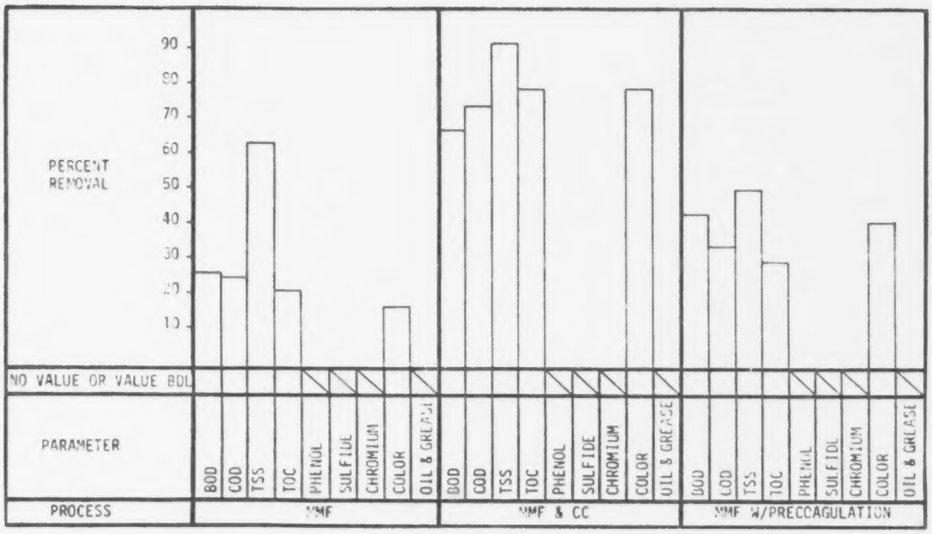


BDL - BELOW DETECTABLE LIMITS

FIGURE 24

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT W

100% Subcategory V

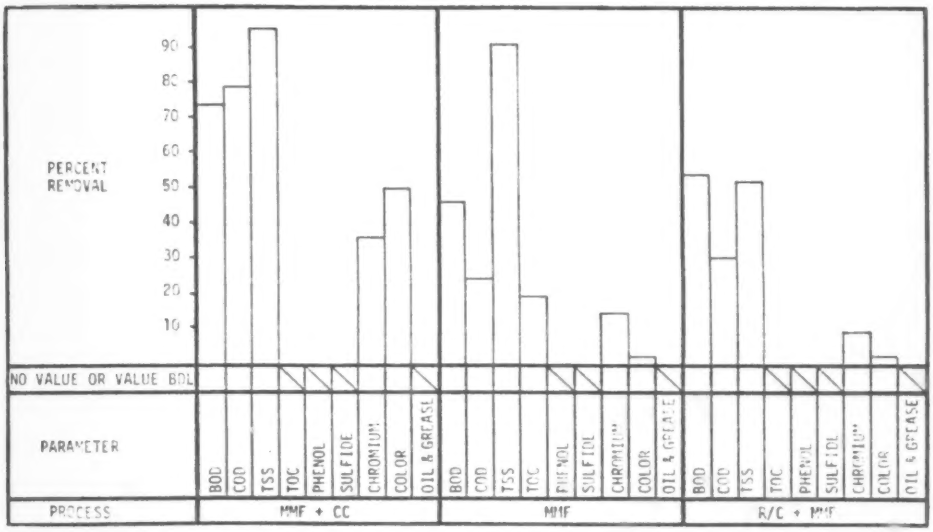


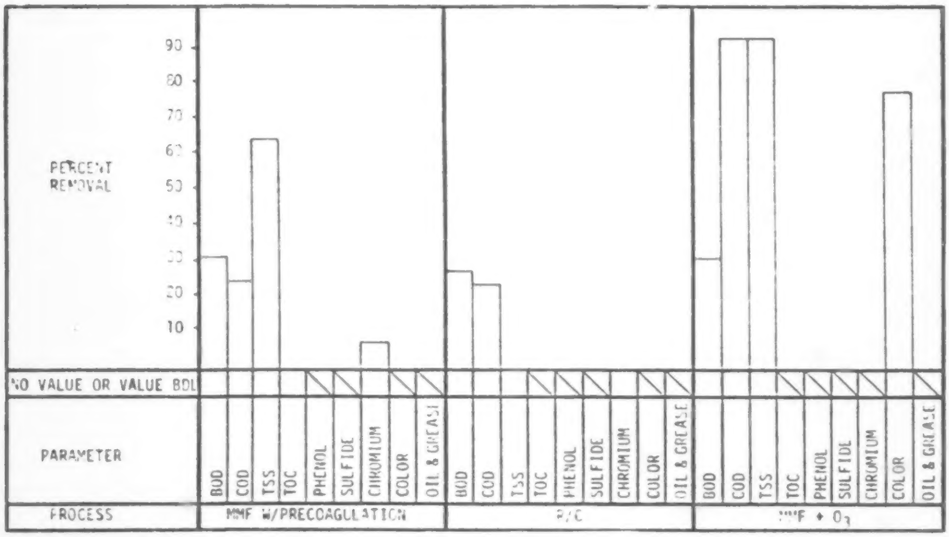
BDL - BELOW DETECTABLE LIMITS

FIGURE 25

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT Q

100% Subcategory V

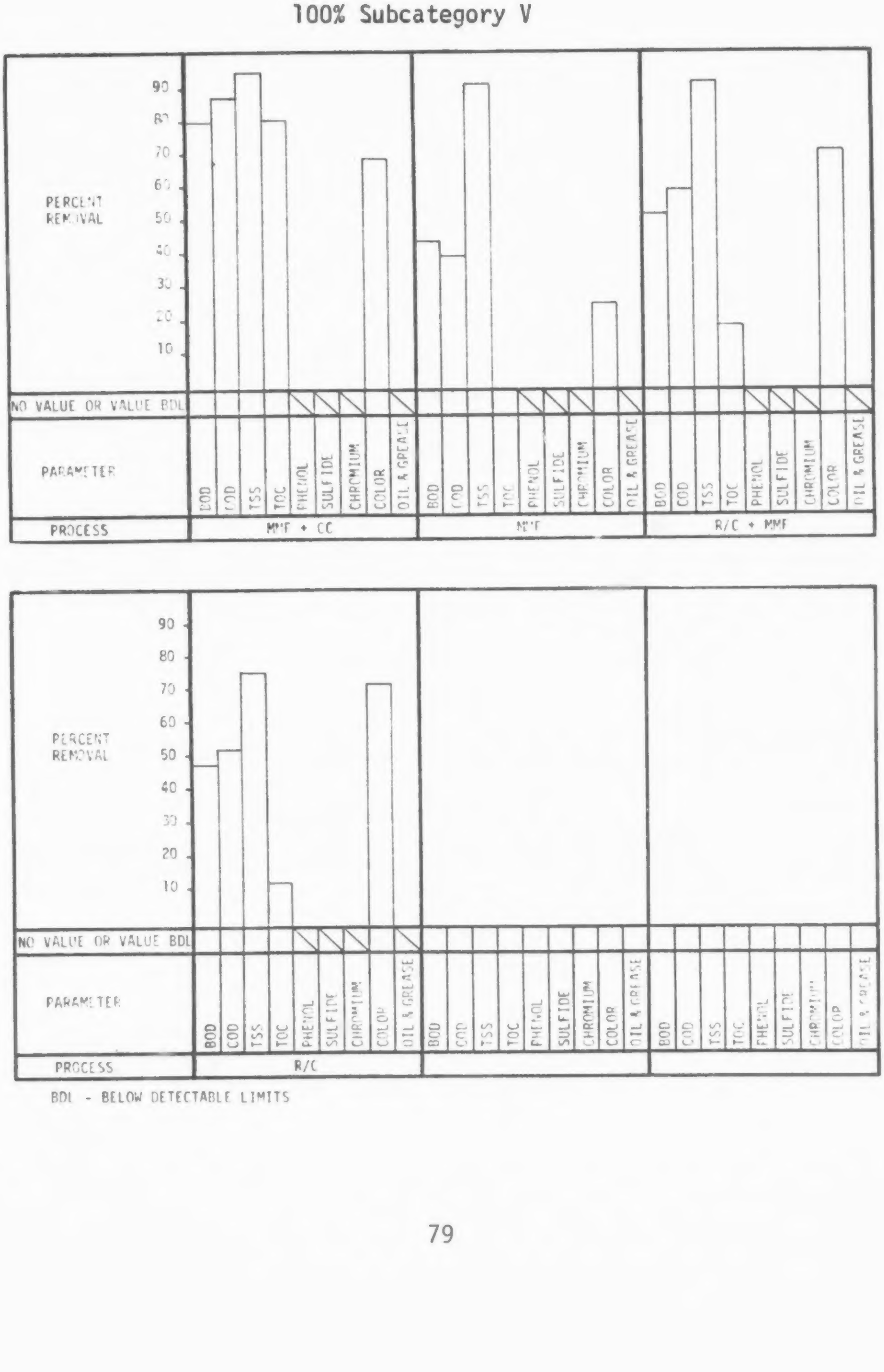




BDL - BELOW DETECTABLE LIMITS

FIGURE 26

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT E

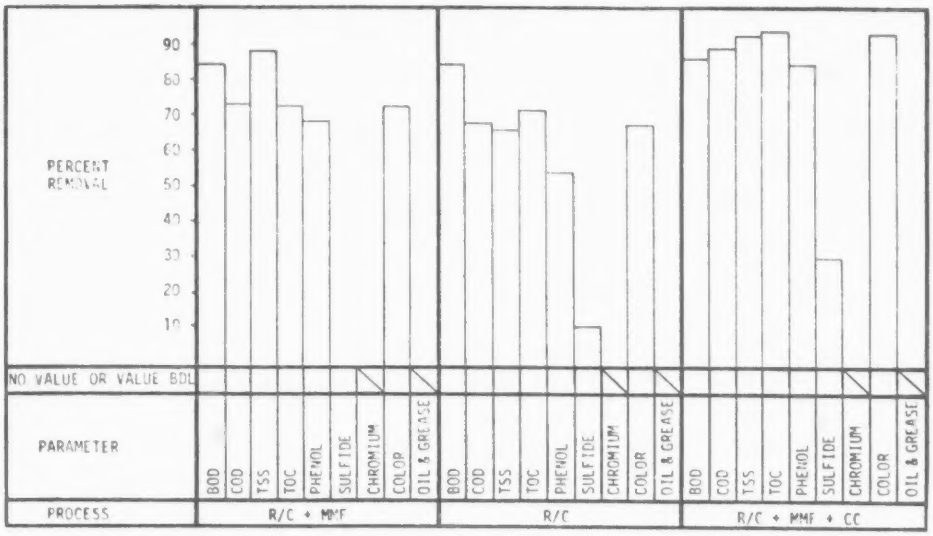


BDL - BELOW DETECTABLE LIMITS

FIGURE 27

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT F

100% Subcategory VI

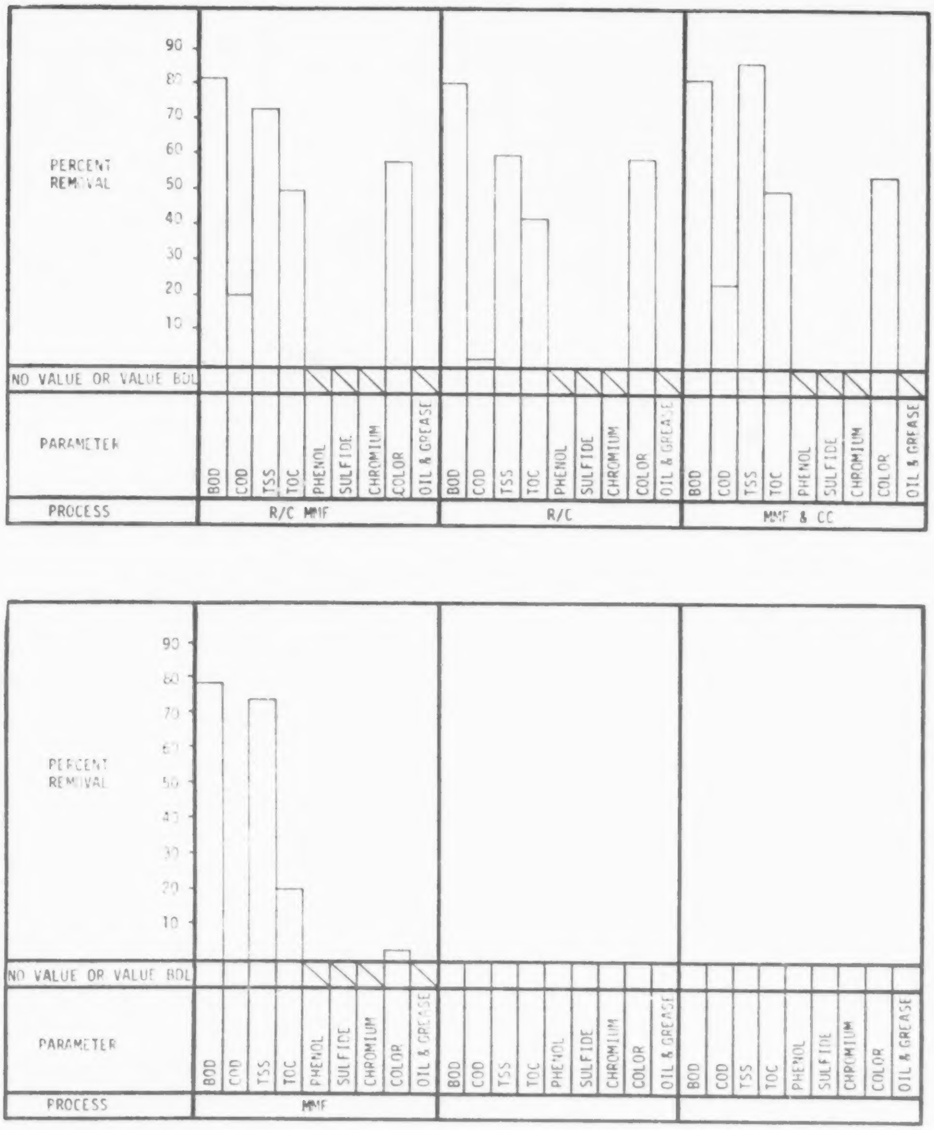


BDL - BELOW DETECTABLE LIMITS

FIGURE 28

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT S

100% Subcategory VII



BDL - BELOW DETECTABLE LIMITS

FIGURE 29

REDUCTION OF POLLUTANTS WITH AWT TECHNOLOGIES TESTED AT PLANT EE

40% Subcategory IV
60% Subcategory VII

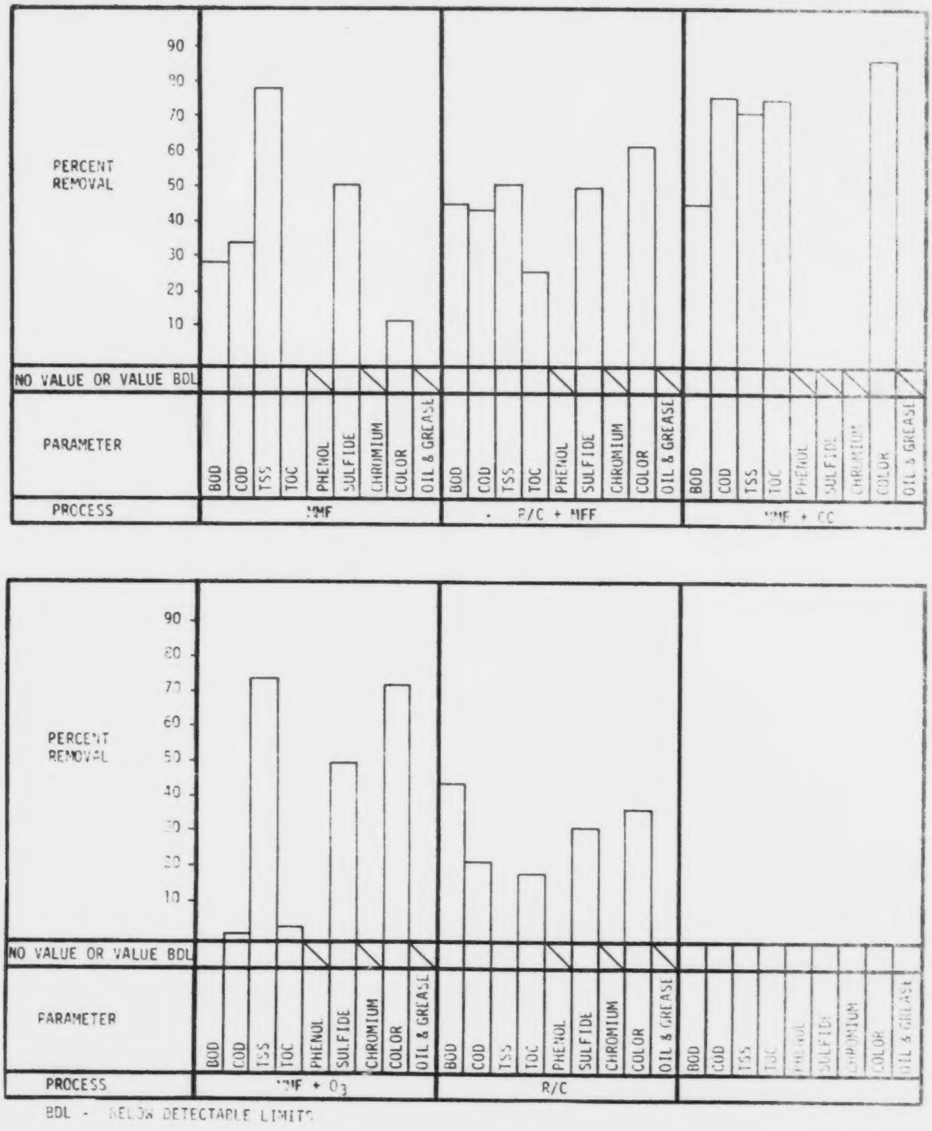
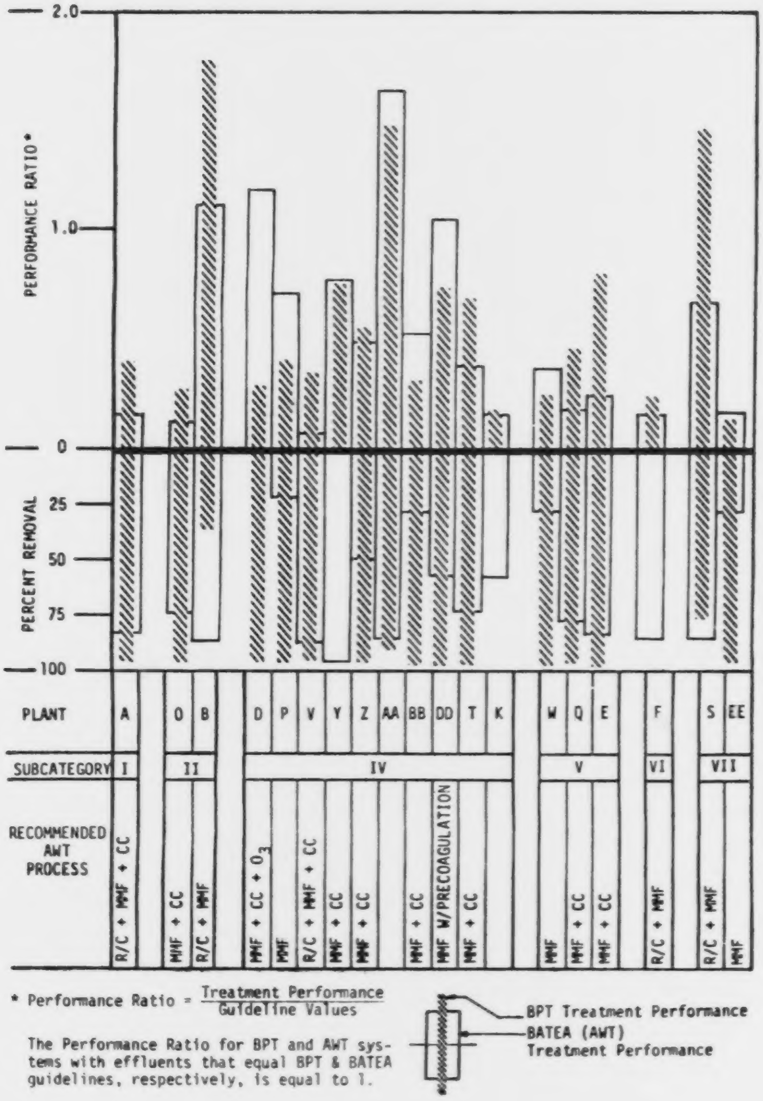


FIGURE 30

BOD REMOVAL EFFICIENCIES AND PERFORMANCE RATIOS FOR RECOMMENDED AWT PROCESSES

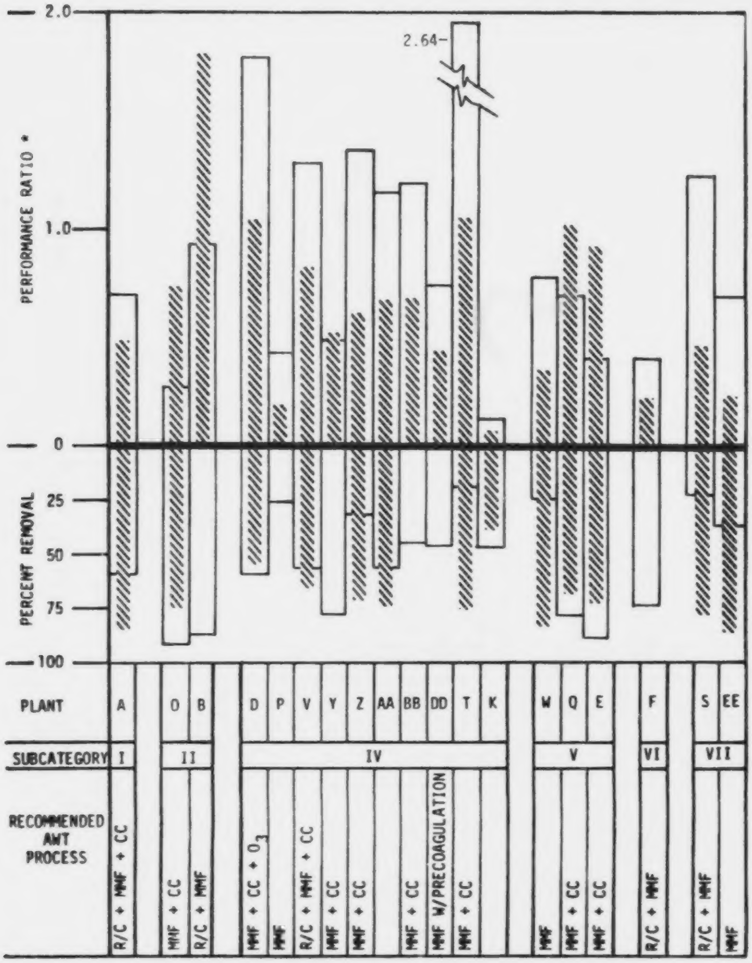


* Performance Ratio = $\frac{\text{Treatment Performance}}{\text{Guideline Values}}$

The Performance Ratio for BPT and AWT systems with effluents that equal BPT & BATEA guidelines, respectively, is equal to 1.

FIGURE 31

COD REMOVAL EFFICIENCIES AND PERFORMANCE RATIOS FOR RECOMMENDED AWT PROCESSES



* Performance Ratio = $\frac{\text{Treatment Performance}}{\text{Guideline Values}}$

The Performance Ratio for BPT and AWT systems with effluents that equal BPT & BATEA guidelines, respectively, is equal to 1.

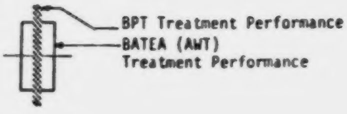
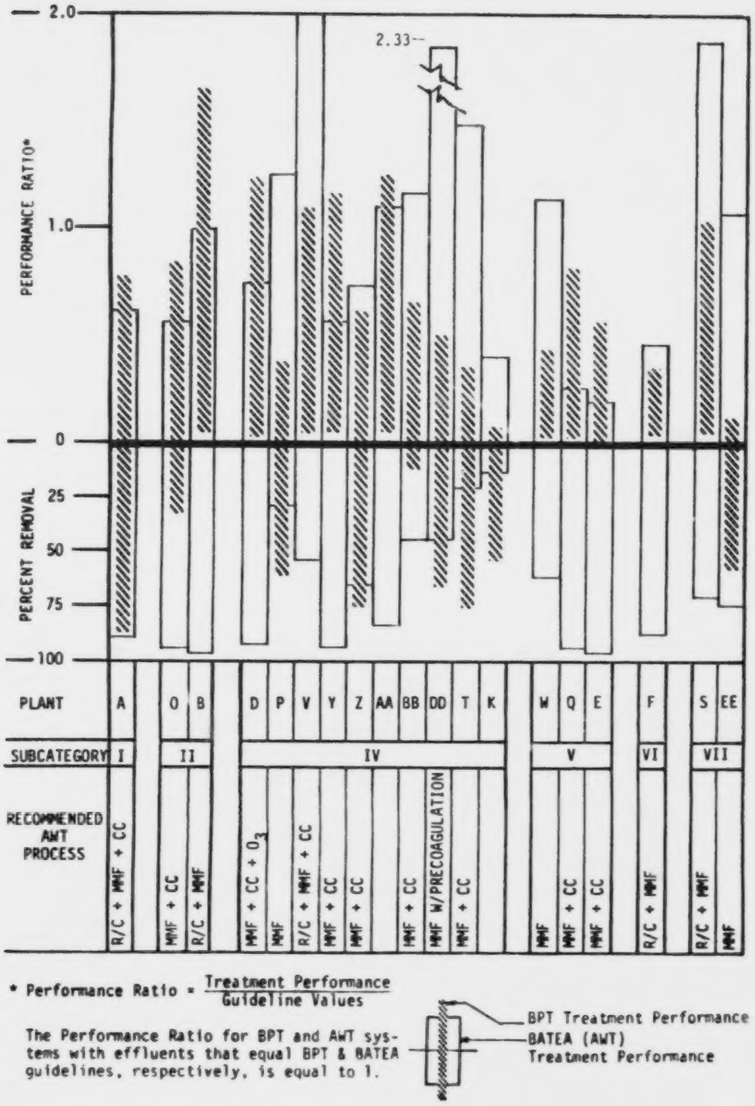

BPT Treatment Performance
BATEA (AWT) Treatment Performance

FIGURE 32

TSS REMOVAL EFFICIENCIES AND PERFORMANCE RATIOS FOR RECOMMENDED AWT PROCESSES

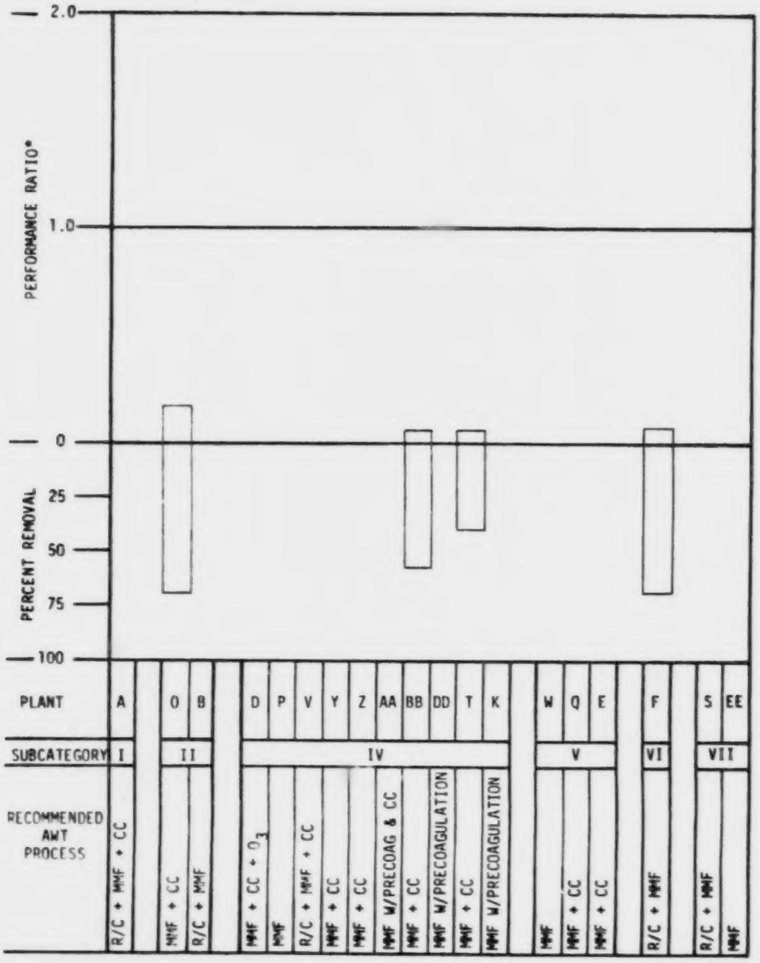


* Performance Ratio = $\frac{\text{Treatment Performance}}{\text{Guideline Values}}$

The Performance Ratio for BPT and AWT systems with effluents that equal BPT & BATEA guidelines, respectively, is equal to 1.

FIGURE 33

PHENOL REMOVAL EFFICIENCIES AND PERFORMANCE RATIOS FOR RECOMMENDED AWT PROCESSES

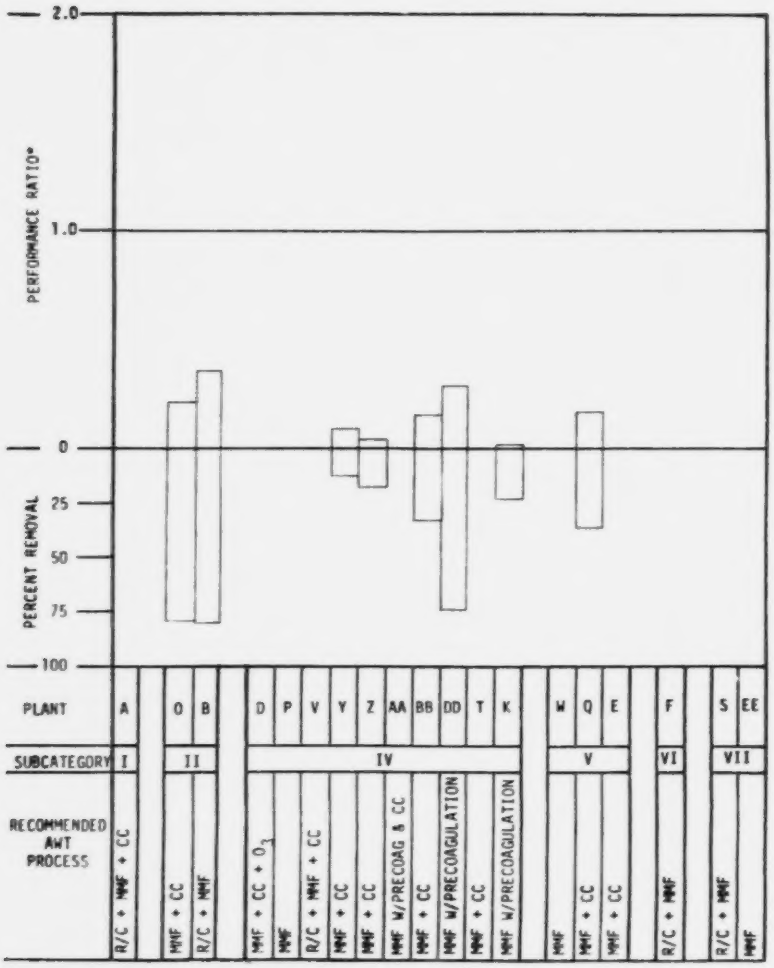


* Performance Ratio = $\frac{\text{Treatment Performance}}{\text{Guideline Values}}$

The Performance Ratio for BPT and AWT systems with effluents that equal BPT & BATEA guidelines, respectively, is equal to 1.

FIGURE 34

CHROMIUM REMOVAL EFFICIENCIES AND PERFORMANCE RATIOS FOR RECOMMENDED AWT PROCESSES

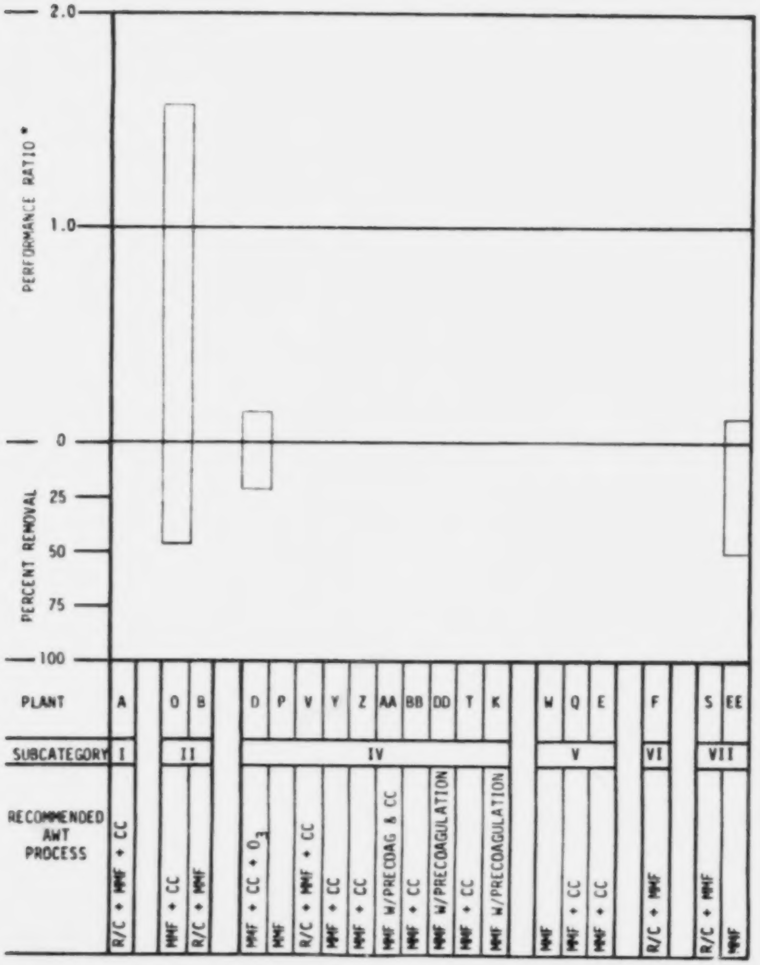


* Performance Ratio = $\frac{\text{Treatment Performance}}{\text{Guideline Values}}$

The Performance Ratio for BPT and AWT systems with effluents that equal BPT & BATEA guidelines, respectively, is equal to 1.

FIGURE 35

SULFIDE REMOVAL EFFICIENCIES AND PERFORMANCE RATIOS FOR RECOMMENDED AWT PROCESSES

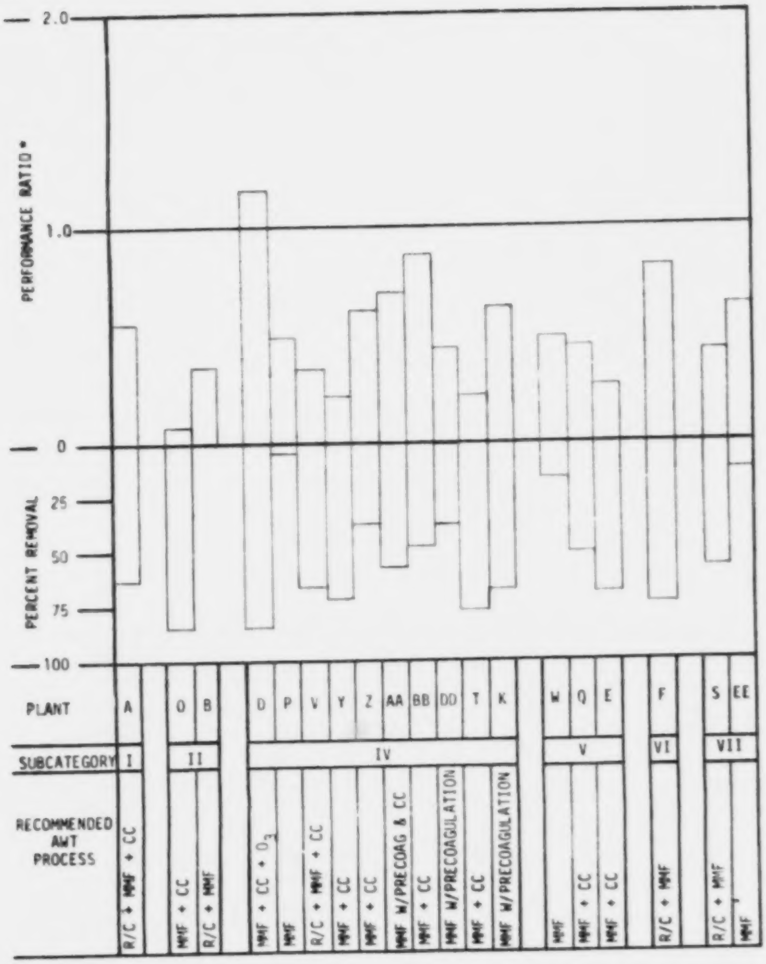


$$* \text{ Performance Ratio} = \frac{\text{Treatment Performance}}{\text{Guideline Values}}$$

The Performance Ratio for BPT and AWT systems with effluents that equal BPT & BATEA guidelines, respectively, is equal to 1.

FIGURE 36

COLOR REMOVAL EFFICIENCIES AND PERFORMANCE RATIOS
FOR RECOMMENDED AWT PROCESSES

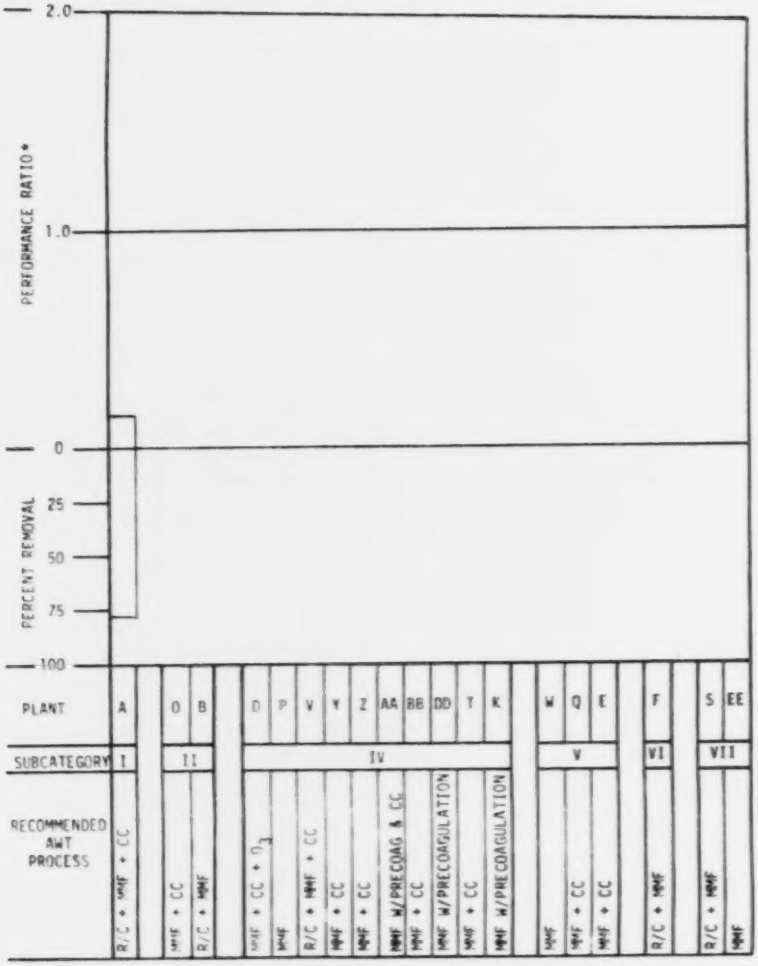


* Performance Ratio = $\frac{\text{Treatment Performance}}{\text{Guideline Values}}$

The Performance Ratio for BPT and AWT systems with effluents that equal BPT & BATEA guidelines, respectively, is equal to 1.

FIGURE 37

OIL AND GREASE REMOVAL EFFICIENCIES AND PERFORMANCE RATIOS FOR RECOMMENDED AWT PROCESSES



* Performance Ratio = $\frac{\text{Treatment Performance}}{\text{Guideline Values}}$

The Performance Ratio for BPT and AWT systems with effluents that equal BPT & BATEA guidelines, respectively, is equal to 1.

CHAPTER VI

RECOMMENDED PROCESS DESIGN

PROCESS SELECTION

The selection of the recommended AWT process was made for each of the 19 textile plants based on the criteria listed below:

> Comparison of the treatment effectiveness of the candidate AWT processes tested at the site.
>
> Comparison of the effluent quality of the candidate AWT processes tested with the BATEA guideline values calculated for the plant.
>
> Comparative evaluation of the capital and operational costs of the candidate AWT processes tested that can technically achieve the BATEA effluent guideline values or if no AWT process is capable of achieving the guideline values then comparative costs of the AWT technologies providing similar effluent quality.

If only one of the AWT processes tested achieved the BATEA guideline values then it was the recommended AWT process for that plant. However, if all or none of the AWT processes could achieve the BATEA guideline values then a comparison of relative treatment effectiveness of the processes and/or capital and operational costs was made in order to select the recommended AWT process. The comparative cost estimates are discussed in greater detail in Chapter VII. Figure 38 illustrates the logic procedure used to arrive at a recommended process selection.

The recommended AWT process was jointly selected by representatives of AMTI, EPA, the host plant and Engineering-Science, Inc., after careful review and evaluation of the pilot plant data.

COMPARISON OF PILOT PLANT DATA TO BATEA GUIDELINE VALUES

The BATEA effluent limitations are given as maximum 30-day average values and maximum daily values. The pilot plant experimental results represent average values over a rather short testing period (approximately 15 days in most cases). Therefore, for comparative purposes a mean effluent from the pilot plant experiment is projected as the long term average, the 90th percentile value is projected as the maximum 30-day average and the 99th percentile value is projected as the daily maximum value. Normal and log-normal distributions were tested for each process parameter and the distribution with the best fit to the data was selected. These projections assume that influent conditions remain the same as those experienced during the pilot plant experiment.

PROCESS DESIGN CRITERIA

The optimum operating conditions of the AWT processes were established during the screening phase of the pilot plant experimental program and confirmed during the continuous operating period at each plant site. Tables 32 through 38 show the optimum operating conditions and removal efficiencies for the technologies evaluated as candidate AWT processes for each of the 19 plants. Table 39 is a summary, by subcategory, of anticipated average efficiencies of the AWT systems developed from the continuous operating data. The operating conditions most likely to achieve the anticipated efficiencies are also listed. Figures 39 through 43 are conceptual process flow diagrams for the individual technologies used to form the AWT treatment trains. The legend for symbols used in the conceptual flow diagrams is presented in Table 40.

Based on the selection of recommended AWT processes and the performance of other candidate advanced waste treatment systems tested at the 19 plants, a process selection and design procedure was developed for textile plants that did not participate in the study. This procedure is detailed in the "Advanced Waste Treatment Process Selection and Process Design" programs previously presented to the ATMI. These packages were developed by subcategory. The objective of these programs was to allow textile plants which did not participate in the study to select a hypothetical AWT system which would be required as a result of implementation of the BATEA guidelines. In addition to this, the programs provided a method establishing AWT unit sizes for each required process. This information was utilized for developing cost estimates for applying the BATEA guidelines and is discussed further in Chapter VII. An example of the AWT Process Selection and Process Design Package is presented in Appendix F.

TABLE 32

REACTOR/CLARIFIER PERFORMANCE AND OPERATING CONDITIONS

SUBCATEGORY	PLANT	OPTIMUM OVERFLOW RATE GPD/SF	COAGULANT SELECTED	COAGULANT DOSAGE MG/L	UNDERFLOW RATE % OF FLOW	REMOVAL EFFICIENCY %							
						BOD	COD	TSS	PHE	SUL	CHR	COLOR	OIL & GREASE
I	A	400	NONE	-	10	34	13	43	-	-	-	1	0
II	O	400	Al^{+3}	7	1	67	35	30	33	43	0	38	-
	B	400	Al^{+3}/Lime	35/100	19	80	78	86	-	-	-	-	-
III	NO SITES TESTED												
IV	D	①											
	P	①											
	V	400	Al^{+3}	40	8	61	10	0	-	-	-	0	-
	Y	①											
	Z	①											
	AA	①											
	BB	①											
	CD	①											
	T	①											
	K	①											
V	W	①											
	Q	400	Al^{+3}/A.P.	20/.75	3	27	23	0	-	-	0	11	-
	E	400	C.P.	20	2	48	53	76	-	-	-	62	-
VI	F	400	C.P./A.P.	35/1	8	85	69	67	54	12	-	68	-
VII	S	400	C.P.	20	2	81	1	60	-	-	-	59	-
	EE	400	Al^{+3}	30	3	44	22	0	-	32	-	37	-

① Indicates Process Not Effective
A.P. = Anionic Polymer; C.P. = Cationic Polymer; Al^{+3} = Alum

TABLE 33

MULTI-MEDIA FILTER PERFORMANCE AND OPERATING CONDITIONS

SUBCATEGORY	PLANT	SURFACE LOADING RATE GPM/SF	REMOVAL EFFICIENCY %							
			BOD	COD	TSS	PHE	SUL	CHR	COLOR	OIL & GREASE
I	A	①								
II	O	3	57	35	84	33	29	0	44	-
	B	①								
III	NO SITES TESTED									
IV	D	4.4	21	23	71		64		0	-
	P	3.0	17	35	24	-	-	-	4	-
	V	①								
	Y	5	20	35	80	-	-	-	1	-
	Z	3	23	7	41	-	-	17	6	-
	AA	①								
	BB	3	12	7	20	33	-	5	10	-
	DD	3	38	13	29	-	-	0	-	-
	T	5	55	3	19	7	0	-	0	-
	K	5	7	14	57	-	-	21	3	-
V	W	7	26	25	63	-	-	-	16	-
	Q	2	46	24	91	-	-	14	1	-
	E	3	44	40	92	-	-	-	25	-
VI	F	①								
VII	S	5	79	0	74	-	-	-	2	-
	EE	7	28	34	78	-	28	-	11	-

① Process Not Effective

TABLE 34

MULTI-MEDIA FILTRATION (FOLLOWING REACTOR/CLARIFIER)

PERFORMANCE AND OPERATING CONDITIONS

SUBCATEGORY	PLANT	SURFACE LOADING RATE GPM/ SF	REMOVAL EFFICIENCY %							
			BOD	COD	TSS	PHE	SUL	CHR	COLOR	OIL & GREASE
I	A	2.0	36	11	45	-	-		8	50
II	O	3.0	17	24	77	20	33	29	40	-
	B	5.4	26	11	55	-	-	20	-	-
III	NO SITES TESTED									
IV	D	①								
	P	①								
	V	3	31	6	61	-	-	-	0	-
	Y	①								
	Z	①								
	AA	①								
	BB	1.5	25	9	37	17	-	0	0	-
	DD	①								
	T	①								
	K	①								
V	W	①								
	Q	3.0	37	8	67	-	-	61	0	-
	E	5	8	15	72	-	-	-	26	-
VI	F	5.0	0	15	68	33	0	-	17	-
VII	S	5.0	0	19	37	-	-	-	0	-
	EE	3.0	0	23	71	-	16	-	39	-

① Process Not Effective

TABLE 35

MULTI-MEDIA FILTER WITH PRECOAGULATION

PERFORMANCE AND OPERATING CONDITIONS

SUBCATEGORY	PLANT	SURFACE LOADING RATE GPM/SF	COAGULANT SELECTED	COAGULANT DOSAGE MG/L	REMOVAL EFFICIENCY %							
					BOD	COD	TSS	PHE	SUL	CHR	COLOR	OIL & GREASE
I	A	①										
II	O	①										
	B	①										
III	NO SITES TESTED											
IV	D	①										
	P	3.0	Al^{+3}	1.5	18	20	NEG			29	NEG	
	V	①										
	Y	①										
	Z	3.0	Al^{+3}	10	23	11	NEG	NEG			NEG	
	AA	3.0	C.P.	0.5	75	22	83				NEG	
	BB	①										
	DD	2.0	Al^{+3}	12	54	45				72		
	T	①										
	K	2.0	$FeCl_3$	16 as Fe	58	46	16	-	-	21	65	-
V	W	5.0	C.P.	3	43	34	50	-	-	-	41	-
	Q	2.5	Al^{+3}	1	31	24	64	-	-	7	-	-
	E											
VI	F	①										
VII	S	3.0	C.P.	13	77	51	36	-	-	-	52	-
	EE	①										

① Process Not Effective; C.P. = Cationic polymer; $FeCl_3$ = Ferric Chloride; Al^{+3} = Alum

TABLE 36

GRANULAR CARBON ADSORPTION (FOLLOWING MMF)

PERFORMANCE AND OPERATING CONDITIONS

SUBCATEGORY	PLANT	CONTACT TIME MINS.	CARBON CAPACITY LB SOD/ LB CARBON	REMOVAL EFFICIENCY %							
				BOD	COD	TSS	PHE	SUL	CHR	COLOR	OIL & GREASE
I	A	45	0.155	55	46	70				57	56
II	O	45	0.230	19	84	58	38	32	76	69	-
	B	25	0.230*	60	80	87			34		
III	NO SITES TESTED										
IV	D	45	0.110*	32	33	73				21	
	P	15	0.110*	11	5				40	60	
	V	45	0.110*	52	47	0				70	
	Y	45	0.104	25	63	80				70	
	Z	49	0.120	29	25	45				34	
	AA	45	0.103	17	42	8				53	
	BB	45	0.110*	17	41	30	34		29	41	
	DD	45	0.110*	0	45	14			52		
	T	60	0.112	29	14	10	55	-	-	73	-
	K	35	0.110	32	69	46	-	-	7	86	-
V	W	45	0.250*	56	65	79	-	-	-	75	-
	Q	35	0.150	57	72	85	-	-	27	62	-
	E	45	0.350	65	80	47				59	
VI	F	45	0.300	14	63	44	50	38	-	77	-
VII	S	35	0.180*	14	32	50	-	-	-	52	-
	EE	45	0.180	20	77	49	-	90	-	86	-

① Process Not Effective

*Information not available. Value given is average for subcategory.

TABLE 37

OZONE (FOLLOWING MMF)

PERFORMANCE AND OPERATING CONDITIONS

SUBCATEGORY	PLANT	CONTACT TIME MINS.	DOSAGE mg/l	LB COD REMOVED PER LB OZONE UTIL	REMOVAL EFFICIENCY %							
					BOD	COD	TSS	PHE	SUL	CHR	COLOR	OIL & GREASE
I	A	45	250	0.304	0	5	18				44	
II	O	①										
	B	33	8	0.327	19	3	0	0	0	0		
III	NO SITES TESTED											
IV	D	①										
	P	①										
	V	①										
	Y	①										
	Z		25-75	0.454	0	5				0	59	
	AA	136	164	0.404	0	24	18				65	
	BB	①										
	DD	①										
	T	①										
	K	25	8	1.178	0	20	33	0	-	-	59	-
V	W	①										
	Q	-	1130-1500	0.142	0	91	33	-	-	0	72	
	E	①										
VI	F	①										
VII	S		60	0.369	0	7	0	-	-	-	64	
	EE		31-277	0.366	0	3	19	-	20	-	71	-

① Process Not Effective

TABLE 38

OZONE (FOLLOWING GRANULAR CARBON ADSORPTION)

PERFORMANCE AND OPERATING CONDITIONS

SUBCATEGORY	PLANT	CONTACT TIME MINS.	DOSAGE mg/1	REMOVAL EFFICIENCY %							
				BOD	COD	TSS	PHE	SUL	CHR	COLOR	OIL & GREASE
I	A	①									
II	O	①									
	B	①									
III	NO SITES TESTED										
IV	D		427	-262	17	30		0		68	
	P	①									
	V	①									
	Y	①									
	Z	①									
	AA	①									
	BB	①									
	DD	①									
	T	①									
	K	①									
V	W	①									
	Q	①									
	E	①									
VI	F	①									
VII	S	①									
	EE	①									

① Process Not Effective

TABLE 39

AWT PROCESS EFFECTIVE OPERATING CONDITION SUMMARY

SUBCATEGORY			VII	VI	V	IV	II	I
GRANULAR CARBON ADSORPTION (FOLLOWING MMF)	OPT. OPER. COND.	CONTACT TIME mins.	45	45	45	45	45	45
		CARBON CAP. # COD/# CARBON						
	REMOVAL EFF.CIENCIES %	BOD	17	14	59	25	40	55
		COD	55	63	48	38	83	46
		TSS	50	44	70	37	73	70
		PHE	50	50		45	38	
		SUL	90	38			32	
		CHR			27	32	55	
		COLOR	69	77	65	57	69	57
		OIL & GREASE						56
MMF W/PRECOAGULATION	OPT. OPER. COND.	CONTACT TIME mins.		①		25	33	45
		DOSAGE mg/l	123		1315	36	8	250
	REMOVAL EFFICIENCIES %	BOD	0		0	0	19	0
		COD	5		91	13	3	5
		TSS	10		33	33	0	18
		PHE				0	0	
		SUL	20				0	
		CHR			0	0	0	
		COLOR	68		72	59		44
		OIL & GREASE						
MMF (FOLLOWING REAC. CLAR)	OPT. OPER. COND.	CONTRACT TIME mins.						
		DOSAGE mg/l	①	①	①	427	①	①
	REMOVAL EFFICIENCIES %	BOD				0		
		COD				17		
		TSS				30		
		PHE						
		SUL				0		
		CHR						
		COLOR				68		
		OIL & GREASE						

① Process Not Effective

(continued)

TABLE 39

(continued)

SUBCATEGORY			VII	VI	V	IV	II	I
REACTOR CLARIFIER	OPT. OPER. COND.	OVERFLOW RATE gpd/sf	400	400	400	250	400	400
		COAGULANT SELECTED	Alum	C.P.	Alum	Alum	Alum	---
		COAGULANT DOSAGE mg/1	25	35	20	80	21	---
	REMOVAL EFFICIENCIES %	BOD	63	85	37	58	74	34
		COD	12	69	38	34	57	13
		TSS	30	67	38	0	58	43
		PHE		54		46	33	
		SUL	16	12			43	
		CHR						
		COLOR	48	68	37	27	38	1
		OIL & GREASE						0
MULTI MEDIA FILTER	OPT. OPER. COND.	SURFACE LOADING RATE gpm/sf	6	①	4	4	3	①
	REMOVAL EFFICIENCIES %	BOD	54		39	24	57	
		COD	17		30	17	35	
		TSS	76		82	43	84	
		PHE				20	33	
		SUL	14			0	29	
		CHR			14	11	0	
		COLOR	7		14	3	44	
		OIL & GREASE						
OZONE (FOLLOWING BPT)	OPT. OPER. COND.	SURFACE LOADING RATE gpm/sf	4	5	4	2.3	4.2	2
	REMOVAL EFFICIENCIES %	BOD	0	0	23	28	22	36
		COD	21	15	12	8	18	11
		TSS	54	68	70	49	66	45
		PHE		33		17		
		SUL	15	0				
		CHR			61	0	20	
		COLOR	20	17	13	0	20	8
		OIL & GREASE						50
OZONE (FOLLOWING MMF)	OPT. OPER. COND.	SURFACE LOADING RATE gpm/sf	3	①	2.5	2.5	①	①
		COAGULANT SELECTED	C.P.		Alum	Alum		
		COAGULANT DOSAGE mg/1	13		1	8		
	REMOVAL EFFICIENCIES %	BOD	77		37	38		
		COD	51		29	31		
		TSS	36		57	5		
		PHE						
		SUL						
		CHR			7	41		
		COLOR	52		41	22		
		OIL & GREASE						

① Process Not Effective

TABLE 40

LEGEND FOR CONCEPTUAL PROCESS FLOW DIAGRAM

FUNCTION SYMBOL SCHEDULE

LETTER	MEANING OF FIRST LETTER	MEANING OF SECOND LETTER	LETTER	MEANING OF FIRST LETTER	MEANING OF SECOND LETTER
A		Alarm	P	Pressure	
C		Control	Q	Quality	Totalize
D	Differential		R		Reducing Record
E		Primary Element	S	Speed or Safety	Switch
F	Flow Rate		T	Temperature	Transmit
H	Hand	High	U	Multi-variable	
I		Indicate	V	Vacuum	Valve
K	Time		W	Torque	Well
L	Level	Low	Y		Relay
M	Motor	Mid	Z	Position	

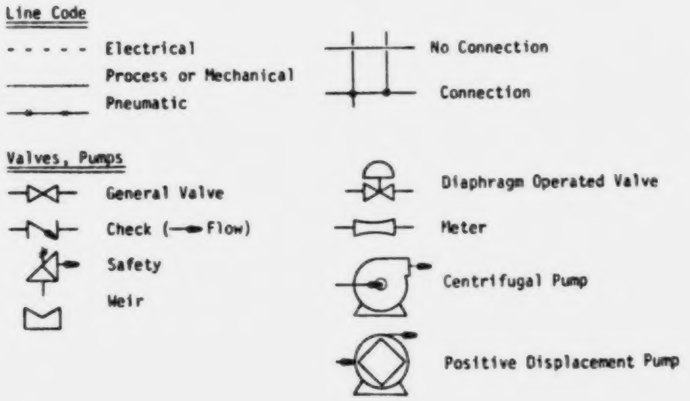
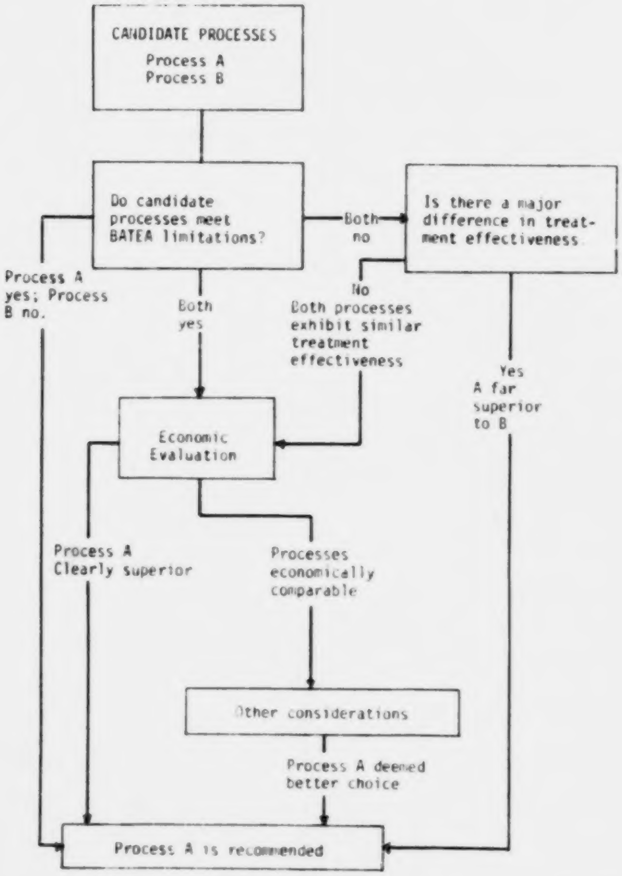

Line Code
Electrical
Process or Mechanical
Pneumatic
No Connection
Connection
Valves, Pumps
General Valve
Check (Flow)
Safety
Weir
Diaphragm Operated Valve
Meter
Centrifugal Pump
Positive Displacement Pump

FIGURE 38

EXAMPLE OF LOGIC SCHEMATIC FOR RECOMMENDED PROCESS SELECTION


CANDIDATE PROCESSES
Process A
Process B
Do candidate processes meet BATEA limitations?
Both no
Is there a major difference in treatment effectiveness
Process A yes; Process B no.
Both yes
No
Both processes exhibit similar treatment effectiveness
Yes
A far superior to B
Economic Evaluation
Process A Clearly superior
Processes economically comparable
Other considerations
Process A deemed better choice
Process A is recommended

Note: This diagram represents the case where Process A is recommended. At any decision level Process B could be determined to be the more attractive and ultimately be chosen through a similar logic sequence.

FIGURE 39

CONCEPTUAL PROCESS FLOW DIAGRAM

REACTOR/CLARIFIER

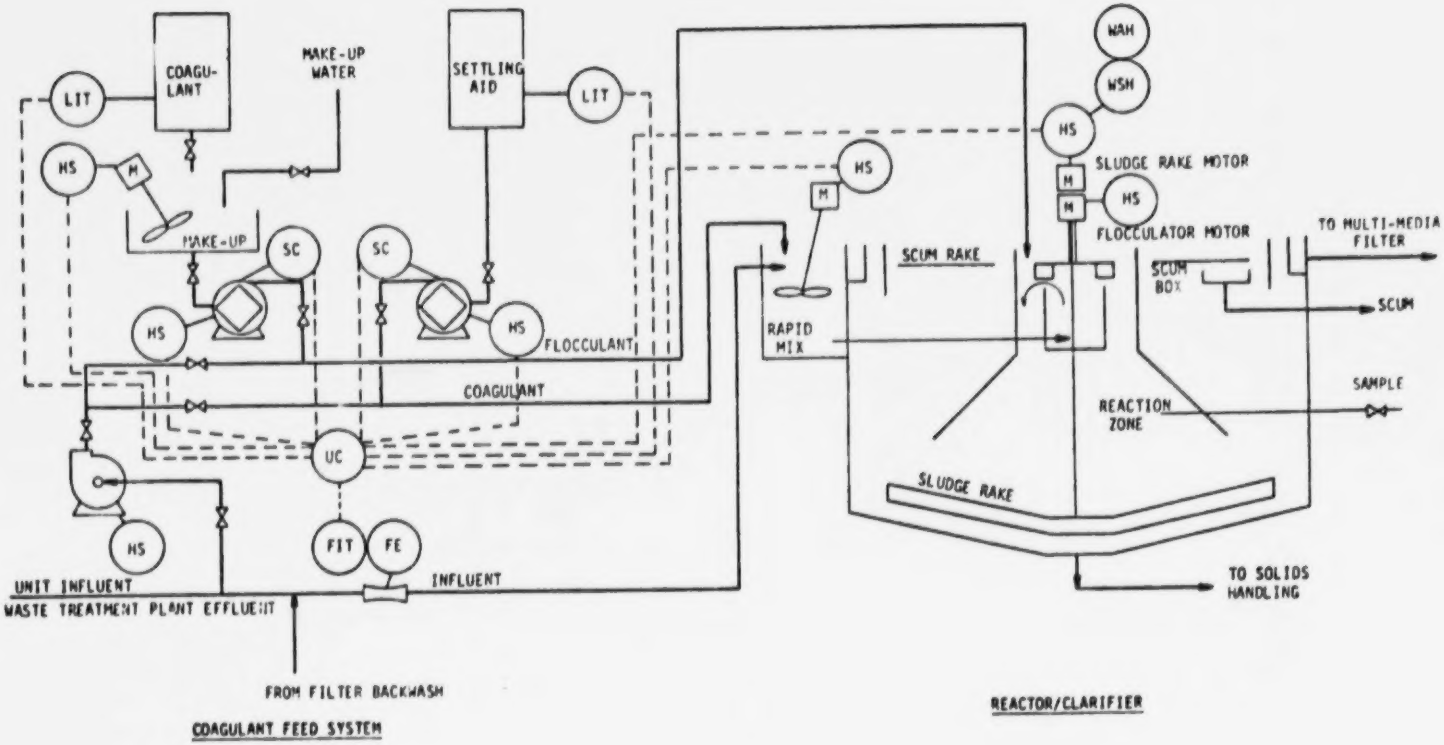

LIT
COAGU-
LANT
MAKE-UP
WATER
SETTLING
AID
LIT
HS
M
MAKE-UP
SC
SC
HS
HS
FLOCCULANT
COAGULANT
UC
HS
FIT
FE
UNIT INFLUENT
WASTE TREATMENT PLANT EFFLUENT
INFLUENT
FROM FILTER BACKWASH
COAGULANT FEED SYSTEM
HS
M
WAH
WSH
HS
SLUDGE RAKE MOTOR
M
M
HS
FLOCCULATOR MOTOR
TO MULTI-MEDIA
FILTER
SCUM RAKE
SCUM
BOX
SCUM
RAPID
MIX
REACTION
ZONE
SAMPLE
SLUDGE RAKE
TO SOLIDS
HANDLING
REACTOR/CLARIFIER

FIGURE 40

CONCEPTUAL PROCESS FLOW DIAGRAM
MULTI-MEDIA FILTER

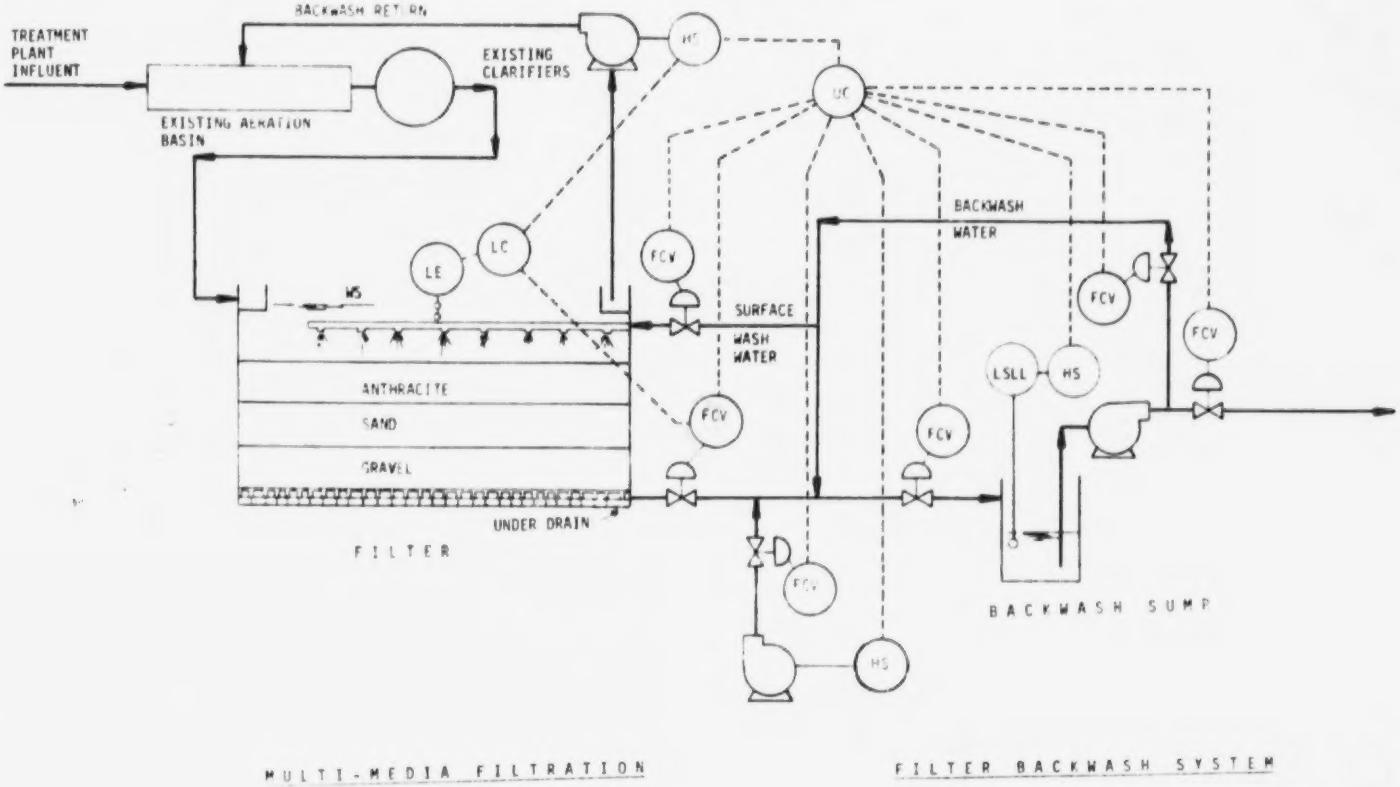
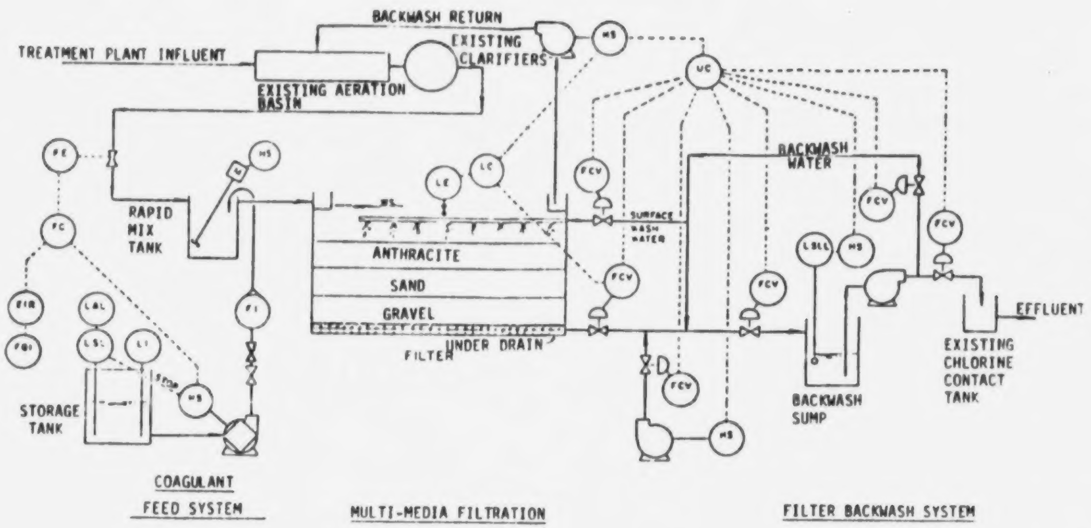

BACKWASH RETURN
TREATMENT PLANT INFLUENT
EXISTING AERATION BASIN
EXISTING CLARIFIERS
HS
UC
LE
LC
WS
FCV
SURFACE WASH WATER
BACKWASH WATER
LSLL
HS
ANTHRACITE
SAND
GRAVEL
UNDER DRAIN
FILTER
BACKWASH SUMP
MULTI-MEDIA FILTRATION
FILTER BACKWASH SYSTEM

FIGURE 41

CONCEPTUAL PROCESS FLOW DIAGRAM
MULTI-MEDIA FILTER WITH PRECOAGULATION



BACKWASH RETURN
TREATMENT PLANT INFLUENT
EXISTING CLARIFIERS
EXISTING AERATION BASIN
MS
UC
FE
FC
RAPID MIX TANK
LE
LC
FCV
SURFACE WASH WATER
BACKWASH WATER
ANTHRACITE
SAND
GRAVEL
FILTER UNDER DRAIN
FIR
FQI
LAL
LSL
LI
FI
STORAGE TANK
LSLL
EFFLUENT
EXISTING CHLORINE CONTACT TANK
BACKWASH SUMP
COAGULANT FEED SYSTEM
MULTI-MEDIA FILTRATION
FILTER BACKWASH SYSTEM

FIGURE 42

CONCEPTUAL PROCESS FLOW DIAGRAM - CARBON COLUMNS

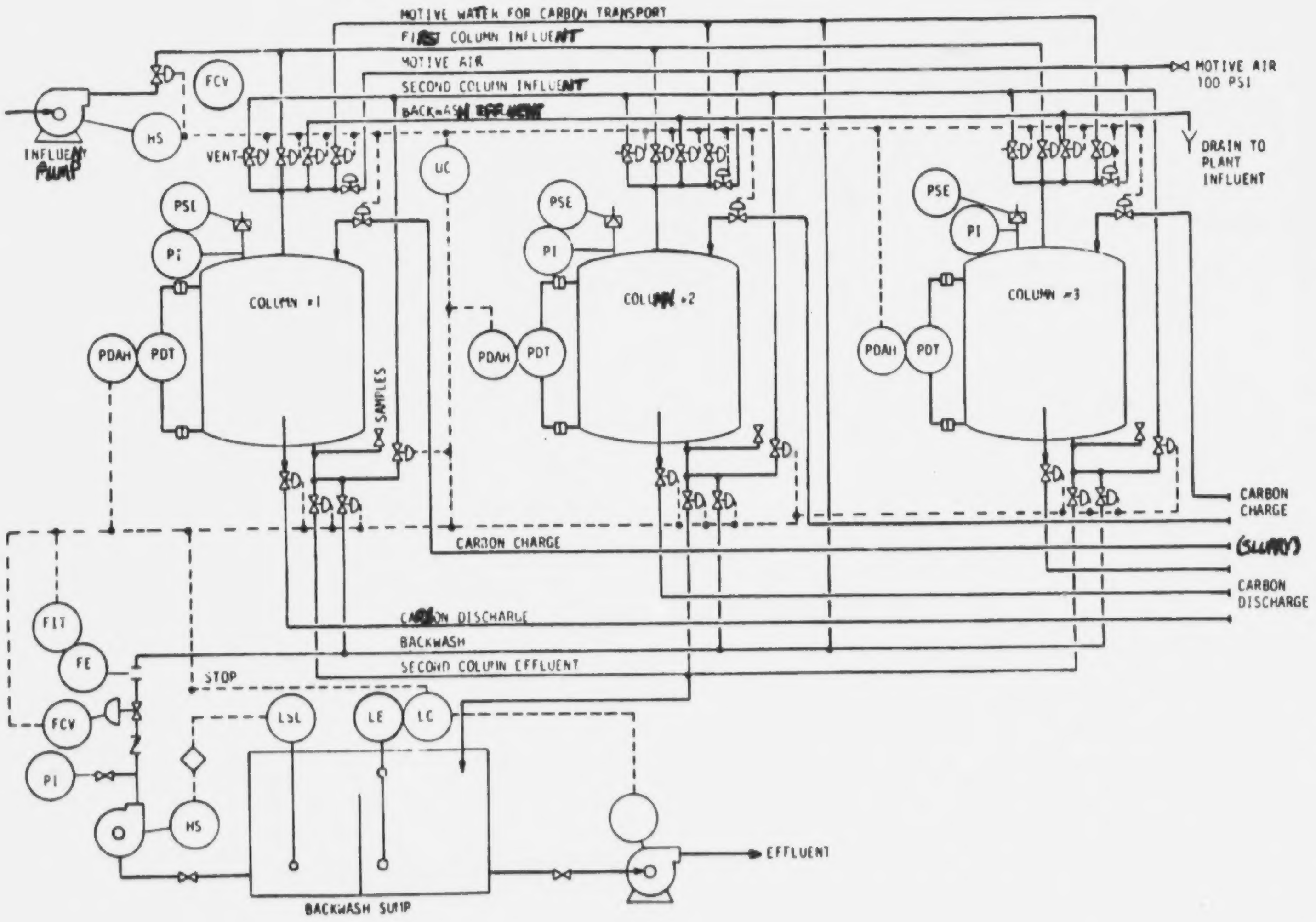
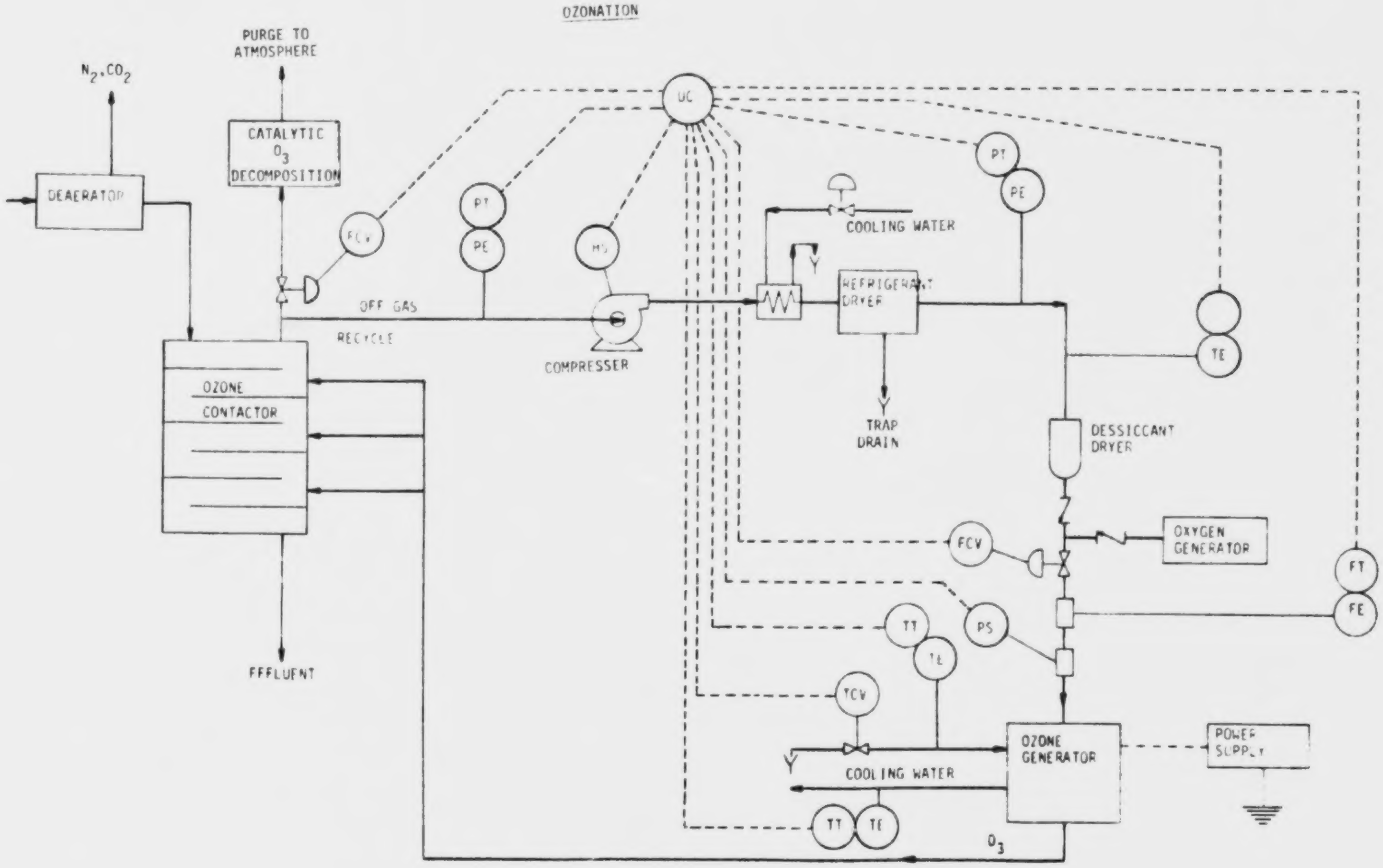

MOTIVE WATER FOR CARBON TRANSPORT
FIRST COLUMN INFLUENT
MOTIVE AIR
SECOND COLUMN INFLUENT
BACKWASH EFFLUENT
MOTIVE AIR 100 PSI
DRAIN TO PLANT INFLUENT
FCV
HS
INFLUENT PUMP
VENT
UC
PSE
PI
PDAH
PDT
COLUMN #1
SAMPLES
PSE
PI
PDAH
PDT
COLUMN #2
PSE
PI
PDAH
PDT
COLUMN #3
CARBON CHARGE
(SLURRY)
CARBON DISCHARGE
CARBON CHARGE
CARBON DISCHARGE
BACKWASH
SECOND COLUMN EFFLUENT
FIT
FE
FCV
PI
STOP
LSL
LE
LC
HS
BACKWASH SUMP
EFFLUENT

FIGURE 43

CONCEPTUAL PROCESS FLOW DIAGRAM - OZONE GENERATOR AND CONTACTOR


OZONATION
N_2,CO_2
PURGE TO ATMOSPHERE
DEAERATOR
CATALYTIC O_3 DECOMPOSITION
FCV
PT
PE
MS
UC
OFF GAS
RECYCLE
COMPRESSER
COOLING WATER
REFRIGERANT DRYER
TRAP DRAIN
PT
PE
TE
OZONE CONTACTOR
DESSICCANT DRYER
FCV
OXYGEN GENERATOR
FT
FE
PS
TT
TE
TCV
COOLING WATER
OZONE GENERATOR
POWER SUPPLY
TT
TE
O_3
EFFLUENT

CHAPTER VII

COST ESTIMATING

INTRODUCTION

Uniform cost estimating procedures were developed to provide consistency of estimating effort throughout the project. Two different levels of cost estimates were developed. The first level provided an estimation of comparative costs. At some of the sites more than one candidate AWT process provided treatment sufficient to meet the BATEA guidelines or more than one AWT process provided a similar degree of treatment but none could achieve the BATEA guideline values. The first level of cost estimating provided an economic means of selecting a recommended AWT process from otherwise equivalent candidate processes and was intended to be only an approximation of the relative costs of equipment installed at idealized sites.

The second level of cost estimating was developed as an "estimating" program which was completed by a group of individual textile mills to estimate the costs of installing and operating AWT technology at specific sites. This second level of estimating was a much more detailed approach and included the application of site specific factors such as topography, unit configurations, materials of construction, power costs, etc. These cost estimates are for AWT technology and do not consider other alternatives such as optimizing or upgrading biological treatment, improving management of manufacturing operations, or in-plant control such as PVA recovery or chemical substitution.

COMPARATIVE COST ESTIMATES

Curves were developed for the purpose of comparing alternative AWT processes and evaluating the cost effectiveness of processes with equivalent treatment effectiveness (Figures 44 through 49). Cost data previously compiled in the EPA study "Appraisal of Powdered Activated Carbon Processes for Municipal Wastewater Treatment" (EPA 600/Z-77-156) as well as additional vendor cost data acquired by Engineering-Science, Inc., formed the basis of the comparative cost curves. The curves included normal costs that would be anticipated at average or idealized sites. Not represented by the curves are costs associated with engineering, legal, administrative, fiscal, other capital items, or the costs associated with site specific factors such as topography and existing site configuration. These items may have a significant influence on the actual estimate of capital and O & M costs for a particular site. For this reason the more accurate procedure for the second level of estimating was developed.

COST ESTIMATING PROGRAM FOR ADVANCED WASTE TREATMENT OF TEXTILE WASTEWATER

This second level of estimating or site specific cost estimating was designed as the second phase of a two-phase "AWT Process Selection and Process Design" program and a "Cost Estimating Program for Advanced Waste Treatment of Textile Wastewater". The first phase, or the process selection program, enabled a textile plant that did not participate in the study to estimate which AWT technologies would be required in order to meet, or come closest to meeting, the presently promulgated BATEA guidelines. The information from the pilot plant study summarized in Chapters V and VI was utilized for developing the "AWT Process Selection and Process Design" program which aided the plants in defining their site specific AWT system. All process selections were reviewed by Engineering-Science, Inc. Plants participating in the pilot plant study estimated costs based on the process(es) defined from the pilot plant site visit.

The second phase of the site specific cost estimating program included estimating the capital and operation and maintenance cost associated with the selected AWT process(es). The cost estimating program was divided into three parts. The first was the "Equipment Selection and Sizing", the second was the "Capital Cost Estimate" and the third was for determining "Operation and Maintenance Costs".

The following is a list of the 11 possible AWT systems that could be selected from the Process Selection Program.

AWT SYSTEM

1 Reactor Clarifier

2 Multi-Media Filter

3 Multi-Media Filter w/Precoagulation

4 Reactor Clarifier and Multi-Media Filter

5 Multi-Media Filter and Ozone

6 Reactor Clarifier and Ozone

7 Reactor Clarifier and Multi-Media Filter and Ozone

8 Multi-Media Filter and Granular Activated Carbon Adsorption

9 Reactor Clarifier and Multi-Media Filter and Granular Activated Carbon Adsorption

10 Multi-Media Filter and Granular Activated Carbon Adsorption and Ozone

11 Reactor Clarifier and Multi-Media Filter and Granular Activated Carbon Adsorption and Ozone

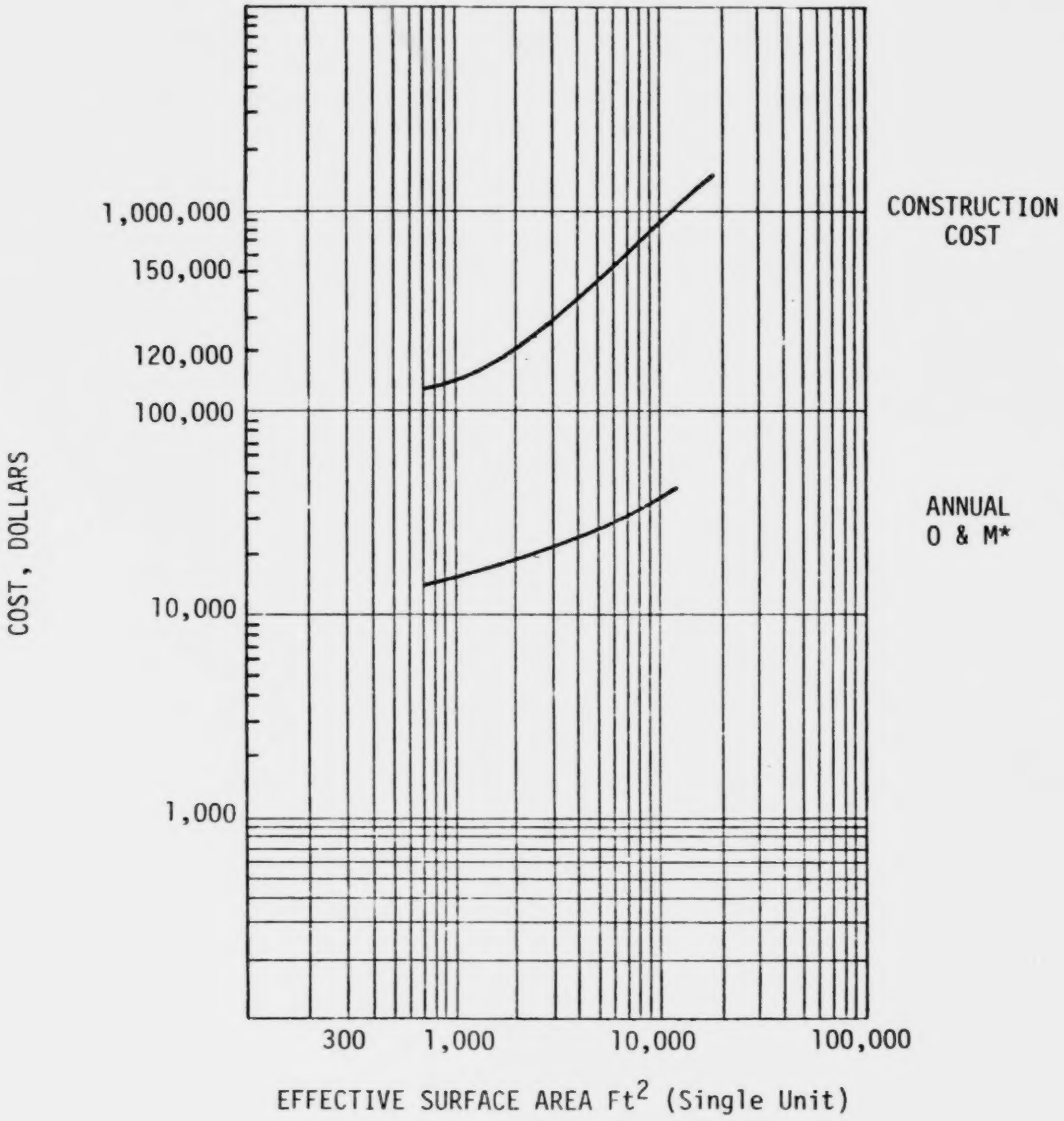
Each of these systems is comprised of one or more of four AWT unit processes; reactor clarifiers, multi-media filters, carbon adsorption and ozone. The first part of the estimating package allowed for selection of equipment configurations and sizes. The second part of the estimating package was designed so that the installed costs of the major equipment involved in each system could be determined. Based on the major equipment configuration and sizing from Part One, a site plan and equipment layout could be developed. The costs of minor equipment, site specific factors including topography, local building codes, site geometry, soils and foundation problems and existing facilities, as well as capital cost items including engineering costs, legal costs and contractor overhead and profit were then added to the major equipment installed cost to provide a total capital cost.

Curves were developed and were included in Part Three of the estimating package which allowed the plants to estimate the annual operation and maintenance costs. Included in the Operation and Maintenance curves were the costs for additional manpower, electricity, maintenance materials and chemical costs.

Appendix F contains the Cost Estimating Program for Advanced Waste Treatment of Textile Wastewater and an example AWT Process Selection and Process Design Program for Subcategory IV.

FIGURE 44

REACTOR CLARIFIER COST CURVES



*Does not include chemical or sludge disposal

FIGURE 45

MIXED MEDIA FILTRATION COST CURVES

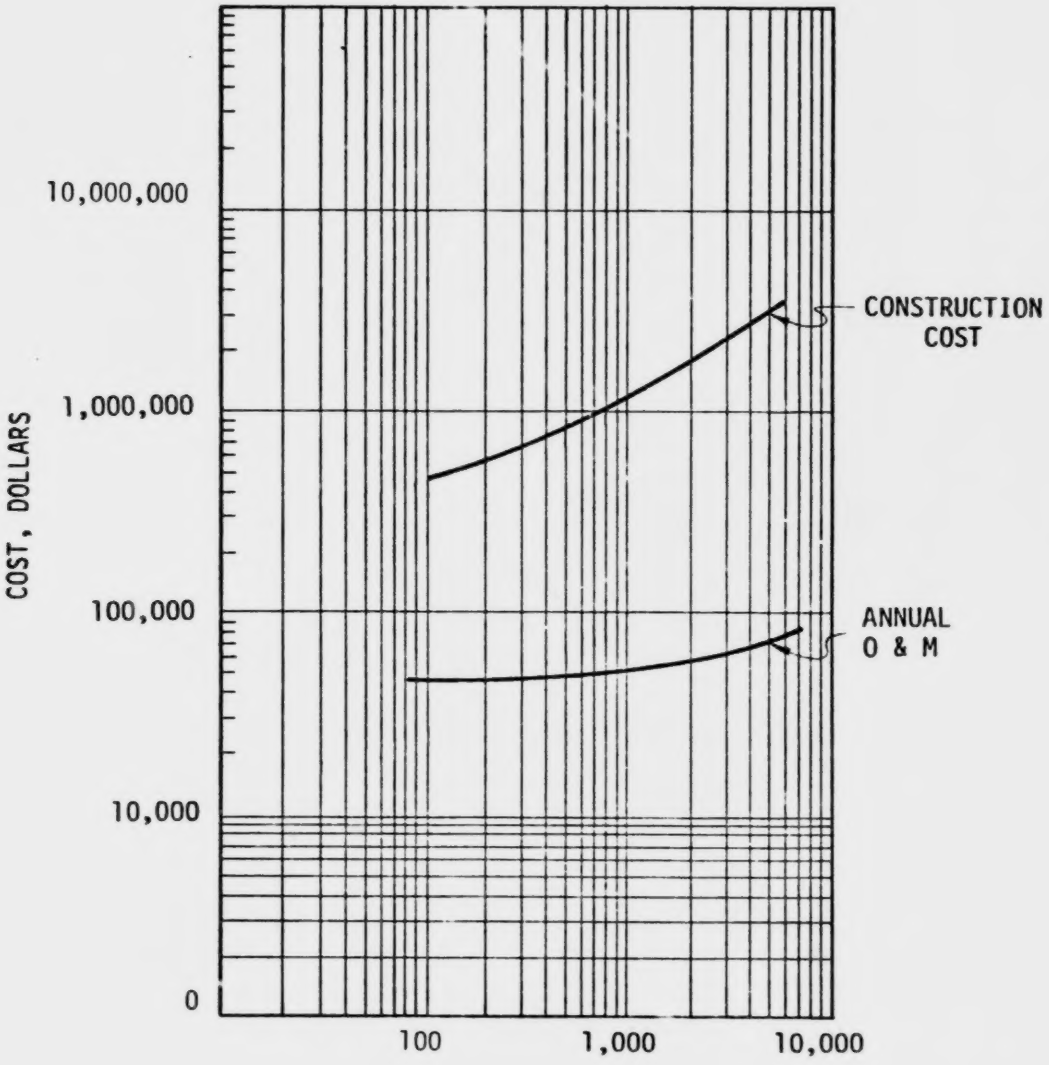
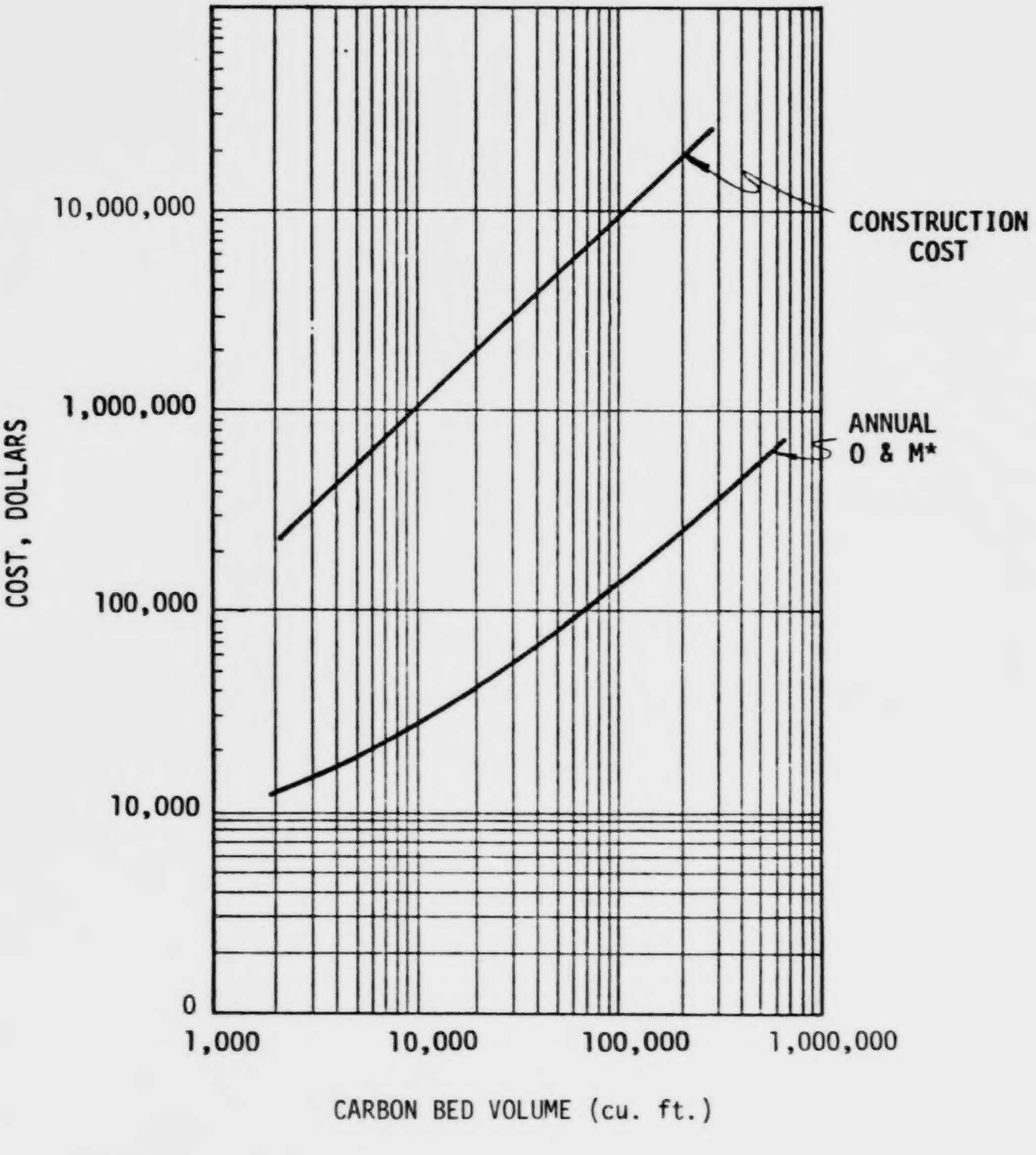


FIGURE 46

CARBON ADSORPTION COST CURVES



*Does not include regeneration or losses

FIGURE 47

CARBON REGENERATION COST CURVES

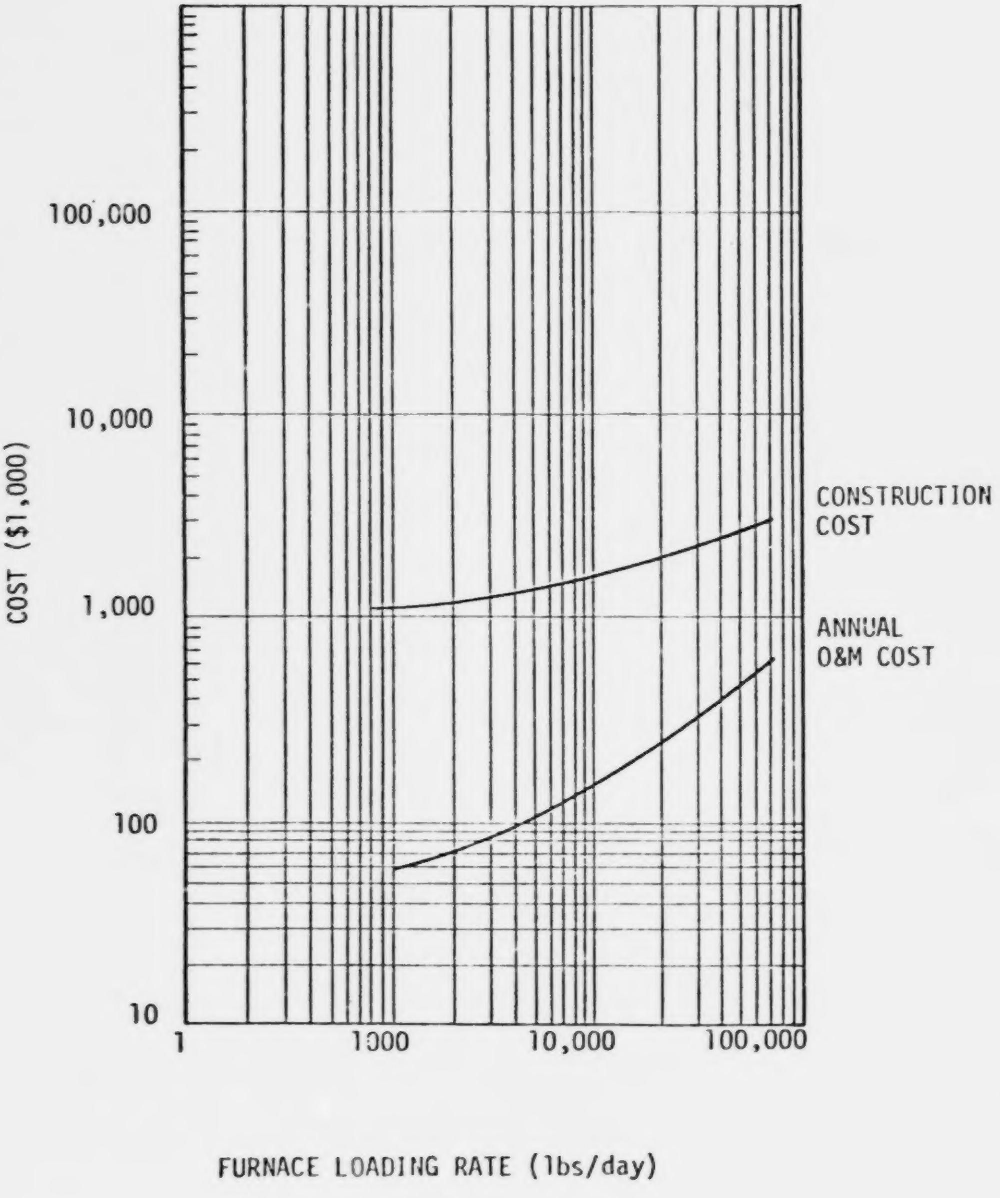


FIGURE 48

OZONE SYSTEM COST CURVES
OZONE CONTACTOR

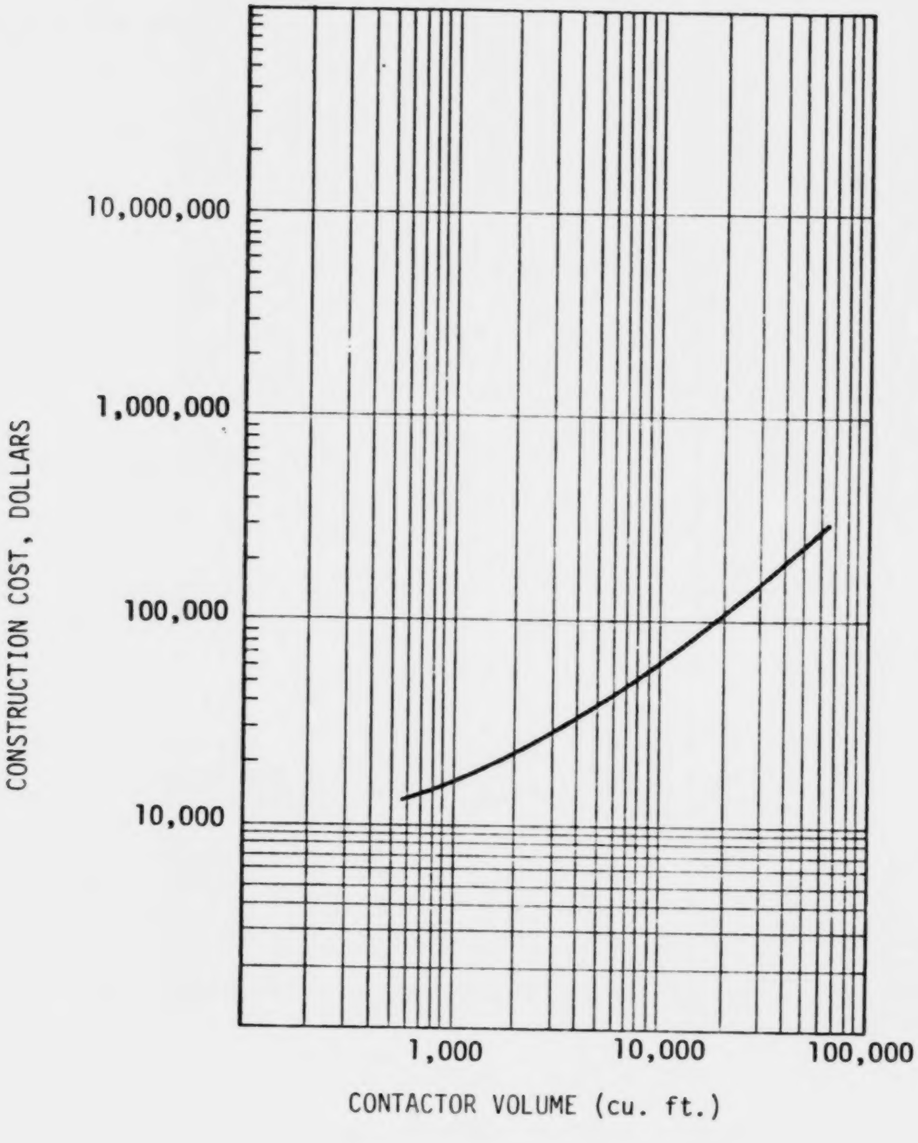
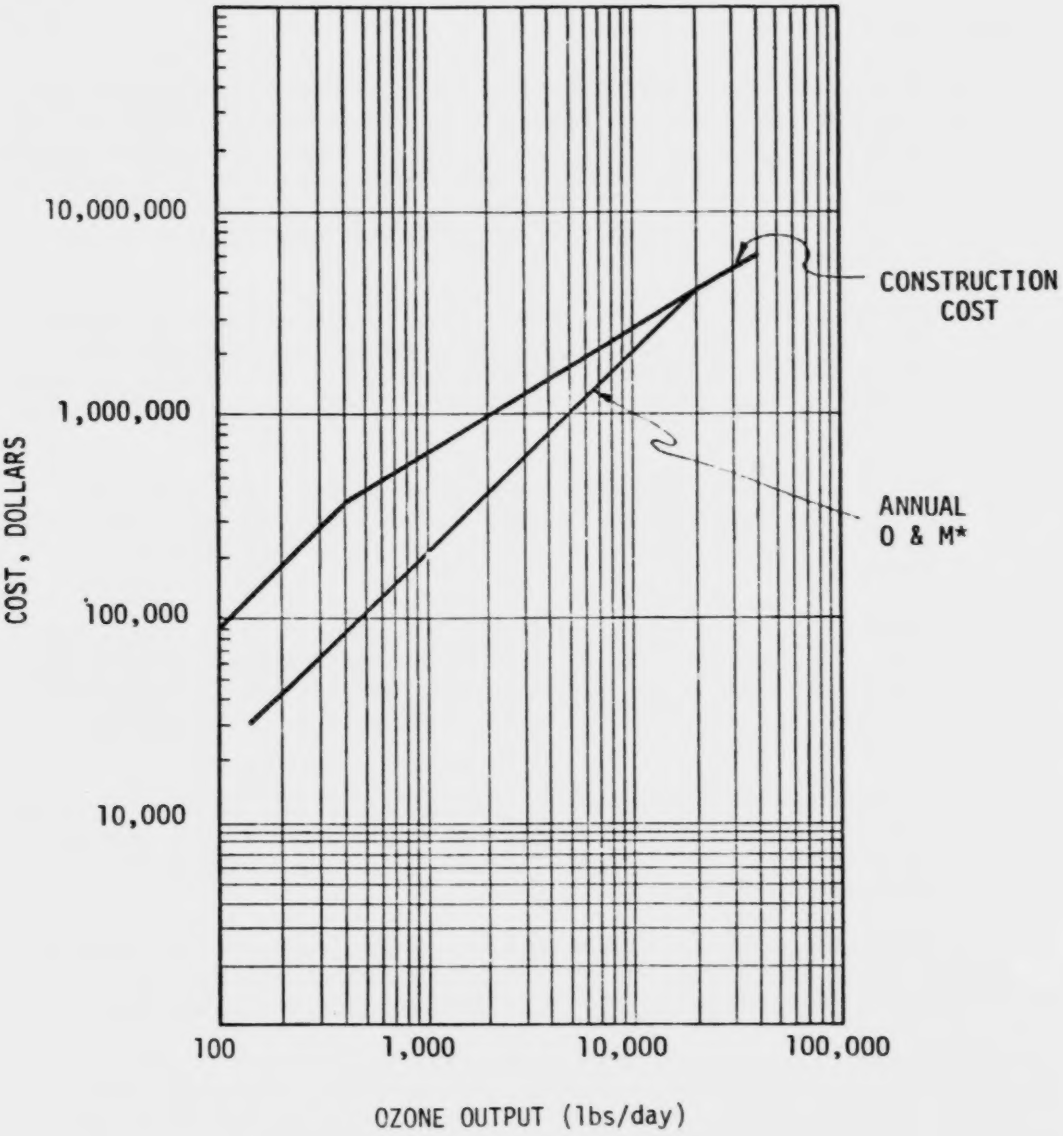


FIGURE 49

OZONE SYSTEM COST CURVES
OZONE GENERATION



CHAPTER VIII

ANALYTICAL QUALITY ASSURANCE PROGRAM

INTRODUCTION

The validity of any study depends on the collection of accurate data; therefore, an analytical quality assurance program was established for the BATEA study to guarantee the proper collection, analysis and record-keeping of the samples. The Quality Assurance (QA) Program required that approximately ten percent of all the samples were to be used to establish the reliability of all the data. The following methods were used to monitor the reliability of the data.

1. Duplicate Samples (approximately five percent of all the samples) - These samples were labeled in such a manner that the identity of the sample was not known by the laboratory. This method was used because it gave quality assurance without overburdening the laboratories.

2. Reference Samples (approximately three percent of all the samples) - Replicate standards were analyzed by each laboratory in order to compare results to a known value and the mean of all laboratories.

3. Round Robin Blind Samples (approximately one percent of all samples) - Blind split samples from each plant participating in the study were sent to all participating laboratories. This method was used to evaluate a laboratory's capability for analyzing an unknown sample.

4. Spiked Samples (approximately one percent of all samples) - Spiked samples ranging from 150 percent to 300 percent of the expected value were analyzed by each laboratory. This method of QA was discontinued during the study.

The procedures used during the QA Program were reviewed and approved by the Process Measurement Branches of IERL/EPA (Research Triangle Park, N.C. and Cincinnati, Ohio) prior to the initiation of program activities.

There were five support laboratories that participated in the pilot plant phase of the study. In addition, the Engineering-Science, Atlanta, Georgia Laboratory performed testing for the PAC studies and color and TOC analyses for the pilot plant studies. All six laboratories were involved in the QA Program. The laboratories are coded A through F for identification in this report.

The results of the QA Program for the entire study period from April, 1977 to September, 1978 are summarized in this chapter. The QA data was entered into a computer system which provided the calculations of percent deviation, average percent deviation and QA charts for the laboratories. The average percent deviation values are reported in absolute numbers.

ESTABLISHMENT OF CONFIDENCE LEVELS

In order to establish the capabilities of all the laboratories which performed the analyses, it was necessary to compare the percent deviation of a laboratory's results to the desired percent deviations.

The desired percent deviations were established from the reference sample data and blind sample data of the first two quarterly reports. The percent deviations listed below represent those values associated with a 95 percent level of confidence.

BOD_5 - 137 percent deviation

COD - 58 percent deviation

TSS - 92 percent deviation

Phenol - 122 percent deviation

Chromium - 63 percent deviation

Sulfide - 134 percent deviation

These values are somewhat higher than normally expected because the absolute concentration values of the above parameters were quite low.

PRESENTATION OF QA DATA

The QA reference sample data, blind sample data and duplicate sample data are summarized in Tables 41, 42 and 43, respectively. Tables 44 through 48 present duplicate sample QA results for each participating laboratory on a plant by plant basis. Table 49 summarizes the program results by presenting the total number of QA samples analyzed by each laboratory and the portion of which were outside of acceptable limits.

The QA data has been computerized in order to calculate the percent deviations and average percent deviations for each laboratory by parameter analysis and the type of QA sample. The data is presented graphically for each laboratory in the QA charts contained in quarterly QA reports presented to ATMI and EPA.

TABLE 41

SUMMARY OF REFERENCE SAMPLE QA DATA

Parameter	95% Conf. Level	LAB C			LAB D			LAB E			LAB B		
		No. Samples Total	No. Samples >95%	Avg. Dev.	No. Samples Total	No. Samples >95%	Avg. Dev.	No. Samples Total	No. Samples >95%	Avg. Dev.	No. Samples Total	No. Samples >95%	Avg. Dev.
BOD_5	137%	4	1	82%	4	0	19%	4	0	16%	4	0	35%
COD	58%	4	1	39%	4	0	8%	4	0	11%	4	0	2%
TSS	92%	10	0	31%	10	1	53%	3	0	12%	11	1	43%
Chromium	63%	6	0	17%	6	0	6%	6	0	12%	6	0	19%
Phenol	122%	22	1	72%	22	5	153%	6	0	59%	15	2	156%
Sulfide	134%	22	1	75%	22	3	173%	6	0	29%	20	1	60%

Parameter	95% Conf. Level	LAB A			LAB F		
		No. Samples Total	No. Samples >95%	Avg. Dev.	No. Samples Total	No. Samples >95%	Avg. Dev.
BOD_5	137%	4	0	24%	4	0	8%
COD	58%	4	0	2%	4	0	2%
TSS	92%	11	0	19%	7	0	10%
Chromium	63%	4	0	2%	-	-	-
Phenol	122%	23	3	65%	12	1	85%
Sulfide	134%	21	3	60%	20	3	78%

TABLE 42

SUMMARY OF BLIND SAMPLE QA DATA

Parameter	95% Conf. Level	LAB C			LAB D			LAB E			LAB B		
		No. Samples Total	No. Samples >95%	Avg. Dev.	No. Samples Total	No. Samples >95%	Avg. Dev.	No. Samples Total	No. Samples >95%	Avg. Dev.	No. Samples Total	No. Samples >95%	Avg. Dev.
BOD_5	137%	39	5	67%	28	1	54%	7	0	46%	39	0	36%
COD	58%	40	4	25%	35	12	49%	11	1	19%	40	4	31%
TSS	92%	38	1	40%	38	7	58%	10	2	72%	39	3	40%
Chromium	63%	29	3	30%	34	3	31%	10	1	44%	39	6	44%
Phenol	122%	28	0	45%	28	3	71%	8	0	34%	34	3	58%
Sulfide	134%	26	1	58%	26	7	91%	9	0	48%	31	0	68%

Parameter	95% Conf. Level	LAB A			LAB F		
		No. Samples Total	No. Samples >95%	Avg. Dev.	No. Samples Total	No. Samples >95%	Avg. Dev.
BOD_5	137%	30	0	43%	32	0	42%
COD	58%	38	5	24%	34	6	29%
TSS	92%	39	0	35%	31	3	43%
Chromium	63%	36	0	21%	-	-	-
Phenol	122%	31	0	53%	13	1	48%
Sulfide	134%	31	0	67%	20	10	164%

TABLE 43

SUMMARY OF DUPLICATE SAMPLE QA DATA

Parameter	95% Conf. Level	LAB C			LAB D			LAB E			LAB B		
		No. Samples		Avg. Dev.	No. Samples		Avg. Dev.	No. Samples		Avg. Dev.	No. Samples		Avg. Dev.
		Total	>95%		Total	>95%		Total	>95%		Total	>95%	
BOD_5	137%	51	0	21%	48	0	8%	12	0	13%	32	0	12%
COD	58%	50	3	16%	68	4	13%	14	0	12%	37	0	7%
SOD	58%	18	1	17%	39	3	14%	-	-	-	7	0	7%
TSS	92%	51	2	22%	65	0	21%	13	0	24%	33	0	18%
Chromium	63%	1	0	11%	34	0	6%	12	0	20%	-	BDL*	-
Phenol	122%	23	0	14%	31	0	14%	-	BDL*	-	3	0	15%
Sulfide	134%	19	0	29%	25	0	13%	-	BDL*	-	-	BDL*	-

Parameter	95% Conf. Level	LAB A		
		No. Samples		Avg. Dev.
		Total	>95%	
BOD_5	137%	28	0	9%
COD	58%	23	0	3%
SOD	58%	-	-	-
TSS	92%	30	0	9%
Chromium	63%	-	BDL*	-
Phenol	122%	-	BDL*	-
Sulfide	134%	-	BDL*	-

*BDL - Below Detectable Limits

TABLE 44

SUMMARY OF DUPLICATE SAMPLE QA DATA

LABORATORY C

Parameter	95% Conf. Level	PLANT P			PLANT S			PLANT AA			PLANT F		
		No. Samples		Avg. Dev.	No. Samples		Avg. Dev.	No. Samples		Avg. Dev.	No. Samples		Avg. Dev.
		Total	>95%		Total	>95%		Total	>95%		Total	>95%	
BOD_5	137%	4	0	38%	12	0	14%	10	0	10%	13	0	20%
COD	58%	3	0	9%	12	1	18%	10	0	9%	13	2	26%
SOD	58%	-	-	-	-	-	-	-	-	-	6	1	35%
TSS	92%	4	0	35%	12	0	31%	10	0	8%	13	1	21%
Chromium	63%	-	BDL*	-	-	BDL*	-	-	BDL*	-	-	0	11%
Phenol	122%	-	BDL*	-	-	BDL*	-	-	BDL*	-	11	0	11%
Sulfide	134%	-	BDL*	-	-	BDL*	-	-	BDL*	-	9	0	35%

Parameter	95% Conf. Level	PLANT T		
		No. Samples		Avg. Dev.
		Total	>95%	
BOD_5	137%	12	0	35%
COD	58%	12	0	9%
SOD	58%	12	0	8%
TSS	92%	12	1	20%
Chromium	63%	-	BDL*	-
Phenol	122%	12	0	18%
Sulfide	134%	10	0	32%

*BDL - Below Detectable Limits

TABLE 45

SUMMARY OF DUPLICATE SAMPLE QA DATA

LABORATORY D

Parameter	95% Conf. Level	PLANT D No. Samples Total	PLANT D No. Samples >95%	PLANT D Avg. Dev.	PLANT EE No. Samples Total	PLANT EE No. Samples >95%	PLANT EE Avg. Dev.	PLANT A No. Samples Total	PLANT A No. Samples >95%	PLANT A Avg. Dev.	PLANT O No. Samples Total	PLANT O No. Samples >95%	PLANT O Avg. Dev.
BOD_5	137%	7	0	5%	2	0	1%	11	0	9%	11	0	10%
COD	58%	9	1	19%	15	3	28%	11	0	7%	17	0	12%
SOD	58%	-	-	-	4	2	41%	9	0	5%	12	1	19%
TSS	92%	8	0	42%	14	0	27%	11	0	20%	16	0	12%
Chromium	63%	-	BDL*	-	2	0	7%	2	0	5%	15	0	6%
Phenol	122%	2	0	49%	-	BDL*	-	-	BDL*	-	13	0	7%
Sulfide	134%	2	0	2%	7	0	14%	-	BDL*	-	13	0	13%

Parameter	95% Conf. Level	PLANT BB No. Samples Total	PLANT BB No. Samples >95%	PLANT BB Avg. Dev.
BOD_5	137%	16	0	9%
COD	58%	16	0	3%
SOD	58%	14	0	7%
TSS	92%	16	0	14%
Chromium	63%	15	0	6%
Phenol	122%	16	0	15%
Sulfide	134%	3	0	22%

*BDL - Below Detectable Limits

TABLE 46

SUMMARY OF DUPLICATE SAMPLE QA DATA

LABORATORY E

	95%	PLANT B		
Parameter	Conf. Level	No. Samples Total	No. Samples >95%	Avg. Dev.
BOD_5	137%	12	0	13%
COD	58%	14	0	12%
SOD	58%	-	-	-
TSS	92%	13	0	24%
Chromium	63%	12	0	20%
Phenol	122%	-	BDL*	-
Sulfide	134%	-	BDL*	-

*BDL - Below Detectable Limits

TABLE 47

SUMMARY OF DUPLICATE SAMPLE QA DATA

LABORATORY B

Parameter	95% Conf. Level	PLANT DD			PLANT Y			PLANT Z			PLANT E		
		No. Samples		Avg. Dev.	No. Samples		Avg. Dev.	No. Samples		Avg. Dev.	No. Samples		Avg. Dev.
		Total	>95%		Total	>95%		Total	>95%		Total	>95%	
BOD_5	137%	4	0	22%	6	0	10%	10	0	12%	12	0	10%
COD	58%	4	0	8%	7	0	5%	14	0	7%	12	0	6%
SOD	58%	-	-	-	-	-	-	7	0	7%	-	-	-
TSS	92%	4	0	25%	5	0	16%	14	0	11%	10	0	26%
Chromium	63%	-	BDL*	-	-	BDL*	-	-	BDL*	-	-	BDL*	-
Phenol	122%	-	BDL*	-	-	BDL*	-	-	BDL*	-	3	0	15%
Sulfide	134%	-	BDL*	-	-	BDL*	-	-	BDL*	-	-	BDL*	-

*BDL - Below Detectable Limits

TABLE 48

SUMMARY OF DUPLICATE SAMPLE QA DATA

LABORATORY A

Parameter	95% Conf. Level	PLANT Q			PLANT V			PLANT A			PLANT W		
		No. Samples Total	No. Samples >95%	Avg. Dev.	No. Samples Total	No. Samples >95%	Avg. Dev.	No. Samples Total	No. Samples >95%	Avg. Dev.	No. Samples Total	No. Samples >95%	Avg. Dev.
BOD_5	137%	6	0	7%	13	0	9%	4	0	6%	5	0	12%
COD	58%	6	0	2%	14	0	0%	5	0	2%	8	0	8%
SOD	58%	-	-	-	-	-	-	-	-	-	-	-	-
TSS	92%	6	0	4%	14	0	9%	2	0	2%	8	0	15%
Chromium	63%	-	BDL*	-	-	BDL*	-	-	BDL*	-	-	BDL*	-
Phenol	122%	-	BDL*	-	-	BDL*	-	-	BDL*	-	-	BDL*	-
Sulfide	134%	-	BDL*	-	-	BDL*	-	-	BDL*	-	-	BDL*	-

*BDL - Below Detectable Limits

TABLE 49

SUMMARY OF SUPPORT LABORATORY QA PERFORMANCE

	Reference Samples						Blind Samples						Duplicate Samples						
Lab	BOD	COD	TSS	Chr	Phe	Sul	BOD	COD	TSS	Chr	Phe	Sul	BOD	COD	SOD	TSS	Chr	Phe	Sul
C	25	25	0	0	5	5	13	10	3	10	0	4	0	6	6	4	0	0	0
	(4)	(4)	(10)	(6)	(22)	(22)	(39)	(40)	(38)	(29)	(28)	(26)	(51)	(50)	(18)	(51)	(1)	(23)	(19)
D	0	0	10	0	23	14	4	34	18	9	11	27	0	6	8	0	0	0	0
	(4)	(4)	(10)	(6)	(22)	(22)	(28)	(35)	(38)	(34)	(28)	(26)	(48)	(68)	(39)	(65)	(34)	(31)	(25)
E	0	0	0	0	0	0	0	9	20	10	0	0	0	0	-	0	0	-	-
	(4)	(4)	(3)	(6)	(6)	(6)	(7)	(11)	(10)	(10)	(8)	(9)	(12)	(14)		(13)	(12)		
B	0	0	9	0	13	5	0	10	8	15	9	0	0	0	0	0	-	0	-
	(4)	(4)	(11)	(6)	(15)	(20)	(39)	(40)	(39)	(39)	(34)	(31)	(32)	(37)	(7)	(33)		(3)	
A	0	0	0	0	13	14	0	13	0	0	0	0	0	0	-	0	-	-	-
	(4)	(4)	(11)	(4)	(23)	(21)	(30)	(38)	(39)	(36)	(31)	(31)	(28)	(23)		(30)			
F	0	0	0	-	8	15	0	18	10	-	8	50	-	-	-	-	-	-	-
	(4)	(4)	(7)		(12)	(20)	(32)	(34)	(31)		(13)	(20)							

Legend: Top Number = % of results reported where the deviation was greater than the maximum allowable for 95% confidence level

(Bottom Number) = Total number of samples analyzed

Chr - Total Chromium

Phe - Phenol

Sul - Sulfide

OBSERVATIONS

The following laboratories reported at least 20 percent of the QA samples outside of the accepted range (confidence level) for the parameters listed below.

a. BOD_5 - Reference Samples: Lab C
Blind Samples: none
Duplicate Samples: none

b. COD - Reference Samples: Lab C
Blind Samples: Lab D
Duplicate Samples: none

c. TSS - Reference Samples: none
Blind Samples: none
Duplicate Samples: none

d. Chromium - Reference Samples: none
Blind Samples: none
Duplicate Samples: none

e. Phenol - Reference Samples: Lab D
Blind Samples: none
Duplicate Samples: none

f. Sulfide - Reference Samples: none
Blind Samples: Lab D and Lab F
Duplicate Samples: none

The average percent deviation (absolute numbers) for each QA sample analysis is listed by participating laboratory in Table 50.

TABLE 50

AVERAGE PERCENT DEVIATION FOR QA ANALYSES BY LABORATORY

REFERENCE SAMPLES AVERAGE PERCENT DEVIATION

	BOD_5	COD	TSS	Phenol	Chromium	Sulfide
Laboratory A	24	2	19	65	2	60
" B	35	2	43	156	19	60
" C	82	39	31	72	17	75
" D	19	8	53	153	6	173
" E	16	11	12	59	12	29
" F	8	2	10	85	-	78

BLIND SAMPLES AVERAGE PERCENT DEVIATION

	BOD_5	COD	TSS	Phenol	Chromium	Sulfide
Laboratory A	43	24	35	53	21	67
" B	36	31	40	58	44	68
" C	67	25	40	45	30	58
" D	54	49	58	71	31	91
" E	46	19	72	34	44	48
" F	42	29	43	48	-	164

DUPLICATE SAMPLES AVERAGE PERCENT DEVIATION

	BOD_5	COD	SOD*	TSS	Phenol	Chromium	Sulfide
Laboratory A	9	3	-	9	-	-	-
" B	12	7	7	18	15	-	-
" C	21	16	17	22	14	11	29
" D	8	13	14	21	14	6	13
" E	13	12	-	24	-	20	-

* SOD = Soluble COD Fraction

APPENDIX A

STATISTICAL VALIDITY AND APPLICATION OF THE DATA

One of the objectives of the study is to collect sufficient pilot scale treatability data at each site to allow projection of treatment process performance for a full scale system at that site. In order to make such a projection, a sufficient number of samples must be taken to allow a valid statistical evaluation of the data.

The values of interest in terms of these projections are the daily average and daily maximum values. These values can be projected based on the means and standard deviations for various parameters observed during the test period. However, a check on the number of samples required to assure that these are valid numbers within a given confidence limit is necessary. In order to determine this, the following method will be used.

General Principles and Definitions

This technique is based on the "t" test or distribution commonly used in engineering statistical analyses, as well as probability, means, and standard deviations. In addition to these typical statistical tools, the following parameters will also be used:

1) D = magnitude of the change in a given parameter (i.e. COD) it is important to detect
2) α = The acceptable risk (% basis) of concluding that a change greater than or equal to D has occurred when it has not.
3) β = the acceptable risk (% basis) of concluding that a change less than D has occured, when in fact a change greater than or equal to D has occurred.

Subjective Inputs and Assumptions

Certain subjective decisions and assumptions must be made to utilize any statistical technique. In this technique the major assumption is that the treatment process behavior during the sampling period is representative of the long term behavior of the process. Thus any long term variations in the conditions are not reflected in the data analysis. Recommended subjective inputs are as follows:

1) D - the magnitude of change it is important to detect will vary from parameter to parameter and must be selected specifically for each site. Examples for Plant P will be given.
2) Probability level of "t" test - 90% probability less than or equal to
3) α = 5% risk
4) β = 5% risk

Estimating Required Number of Samples

Using the subjective input information and knowing the expected standard deviation for various parameters based on the historical BPT effluent data, the required numbers of samples can be determined as follows:

$$U = \frac{D}{\sigma} \quad \text{or} \quad \frac{\bar{X}_1 - \bar{X}_2}{\sigma}$$

Where U = factor calculated from which number of samples required is determined

$\bar{X}_1 - \bar{X}_2$ = magnitude of difference between the means (influent and effluent) one wants to detect

σ = historic standard deviation for given parameters

Once U is calculated, Table 6.11 on page 130 and 131 of Vollk, Applied Statistics for Engineers, McGraw-Hill, 1958, can be used to determine the required number of samples for a 't" test level of 90%, α = 5%, and β = 5% (See Table A-1).

An example using Plant P (1st β trailer site) would be as follows:

COD Basis - BPT Effluent - $\bar{X}_1$ = 100 mg/l

σ = 30 mg/l

Carbon Column Effluent - $\bar{X}_2$ = 50 mg/l

$$U = \frac{100-50}{30} = 1.67$$

From Table 6.11, required number of samples is 10.

TABLE A-1

REQUIRED NUMBER OF OBSERVATIONS, CONTRIBUTING TO THE MEAN, FOR 90% CONFIDENCE LEVEL

Level of t test = 0.10

Unsymmetrical test

Acceptable Risk - $\alpha = 0.05$

Acceptable Risk - $\beta = 0.05$

$(\bar{X}_1-\bar{X}_2)/\sigma$	Number of Observations
0.45	108
0.50	88
0.55	73
0.60	61
0.65	52
0.70	45
0.75	40
0.80	35
0.85	31
0.90	28
0.95	25
1.00	23
1.1	19
1.2	16
1.3	14
1.4	12
1.5	11
1.6	10
1.7	9
1.8	8
1.9	7
2.0	7
2.1	6
2.2	6
2.3	5
2.4	5
2.5	5
3.0	4
3.5	3
4.0	

NOTE:

Based on information in article by G. P. Sillitto in J. Roy Statis. Soc., Research 1 (1948).

Another example using suspended solids as a parameter would be as follows:

TSS - BPT Effluent - $\bar{X}_1 = 20$ mg/l

$\sigma = 15$ mg/l

Multimedia Filter Effluent - $\bar{X}_2 = 5$ mg/l

$$U = \frac{20 - 5}{15} = 1.0$$

From Table 6.11, required number of samples = 23

Based on these examples and review of other data, ES believes that 14 samples during the last two weeks operation will be adequate most of the time. However, due to the inherent differences between wastewaters and specific parameter concentrations such as COD and TSS, ES recommends that during the last two weeks of testing, 12 hour composites be collected, thus providing up to 28 samples for analysis. This should insure that adequate samples will have been collected in each case.

Daily Average and Maximum Values

The mean or average value expected for a given parameter will actually be the mean determined for the test period and will have associated with it a given confidence limit. The daily maximum will be estimated using a probablistic approach as follows:

Daily Max. = $\bar{X} + Z(\sigma)$

where : $\bar{X}$ = mean effluent for a given parameter

σ = effluent std. deviation for a given parameter

Z = σ enhancement factor from Table I of Davies, 1972, p. 460

A typical probability for the extreme maximum value occurring within a given month might be 5% for example. The confidence limits for this value can be determined from the variance observed during the test period, just as with the mean value.

This technique of data collection and handling can be used to make statistically valid projections of daily average and daily maximum values from the possible BATEA processes. However, these projections are valid only when the BPT effluent quality is within the range of conditions that were actually tested during the final two weeks of the site visit. Projections where the BPT effluent quality lies outside this range cannot be made using statistically valid techniques.

APPENDIX B

PILOT STUDY EXPERIMENTAL PROGRAM

I. Coagulant Screening/Selection

- A. Purpose/Concept - Preliminary screening to identify the type of coagulant (s) and dosage most effective for removing suspended solids and organic material from the BPT discharge. Investigations are generally performed in the ES Atlanta Lab on wastewater shipped from the site, prior to arrival of the trailer.
- B. Jar Testing
  - 1. Alum
    - a. Perform total and phenolphthalein alkalinity analyses and determine dominant wavelength of BPT effluent.
    - b. Add 0, 1, 5, 10, 20, 35, and 50 mg/l Alum as Al
    - c. Adjust pH to 6.5
    - d. Rapid mix @ 100 rpm, 1 min.
    - e. Slow mix @ 20 rpm, 5 min.
    - f. Settle 30 min.
    - g. Note lowest dosage where floc forms
    - h. Note lowest dosage where floc settles within 30 min.
    - i. Measure transmittance of supernatant and observe color reduction in each jar
    - j. Allow jars to sit for 1 hour and note floating sludge, if any
    - k. Plot transmittance vs Al dosage
    - l. Repeat steps a. → k. at pH = 7.0 and 7.5
  - 2. Ferric Chloride (Same as B.1.a → l., except only at pH = 5.5, 6.0, and 6.5)
  - 3. Alum + Anionic Polymer
    - a. Add 0 → Dosage from B.1.g mg/l as Al
    - b. pH = Optimum from B.1.
    - c. Rapid mix @ 100 rpm, 1 min.
    - d. Slow mix @ 20 rpm, 5 min.
    - e. Add 1 mg/l anionic polymer
    - f. Rapid mix @ 100 rpm, 1 min.
    - g. Slow mix @ 20 rpm, 5 min.
    - h. Settle 30 min.
    - i. Note lowest dosage where floc forms
    - j. Note lowest dosage where floc settles in 30 min.
    - k. Measure supernatant transmittance and observe color reduction

    1. Plot transmittance vs dosage Al

4. Ferric Chloride + Anionic Polymer (Same as B.3.a. → 1.)
5. Cationic Polyelectrolytes
    a. Add 10, 25, and 50 mg/l Cyanamid cationic polymers (509C, 515C, 581C, etc.)
    b. Add 10, 25, and 50 mg/l Hercules cationic polymers (various products)
    c. Rapid mix @ 100 rpm, 1 min.
    d. Slow mix @ 20 rpm, 5 min.
    e. Note floc formation, if any
    f. Note dosage that floc settles, if any
    g. Measure supernatant transmittance and observe color reduction
6. Cationic + Anionic Polyelectrolytes (Same as 7.a. → g., except to dosage and product from 7.e. add 1 mg/l anionic polymer after step d., followed by rapid mix and slow mix)
7. Lime, Alum + Lime, or Ferric Chloride + Line
   Lime can be used as a coagulant itself or in combination with Alum or Ferric Chloride. Add lime to reach pH = 11.0, record lime quanity and let settle for 30 min. Measure transmittance of supernatant. If Alum or Ferric Chloride gave poor results, use Lime with them as a weighing agent at pH ≈ 7.0
8. Recommend the optimum coagulant combination for clarification and for filtration based on transmittance vs dosage plots and visual observations.
9. Sludge Mass Determination
    a. Perform jar test using recommended coagulant combination and dosage for clarification in triplicate
    b. Let settle, note volume of sludge and decant liquid from each jar
    c. Determine mass of sludge produced through total suspended solids or total solids analysis
10. Perform comparative carbon isotherms on BPT effluent using Westvaco and ICI carbons available for use in trailer.
    a. Wash approximately 10 grams of each powdered activated carbon to be evaluated with distilled water to remove fine dust and dry at 103°C for 24 hours. If only granular carbon is available, pulverize it as uniformly as possible prior to washing and drying.
    b. To each of six beakers add 500 ml of wastewater to be tested.

c. Add various weights of dried carbon to five of the beakers and use the sixth as a control with no carbon added. (Range of carbon concentrations to be tested is somewhat a function of the organic concentration of the wastewater, but a typical range is 500 to 10,000 mg/l.)

d. Stir each beaker at 70 - 90 rpm for two hours.

e. Allow the carbon suspensions to settle and filter sufficient supernatant using an 0.45 micron glass fiber filter for the analyses required.

f. Perform required analyses on filtered initial wastewater (blank) and each filtered supernatant. (Typical analyses include TOC and percent transmittance.

g. Results should be presented graphically using one of several isotherm plots. The most common is the Freundlich Isotherm plot where X/M and C are the Y and X axes, respectively, plotted on log-log paper.

  X - grams TOC removed $(C_o - C)$ X Volume
  M - grams carbon in the sample
  C - equilibrium concentration of TOC

h. Recommend carbon for use in the carbon adsorption experiment, Mode B.

II. Mode A

A. Purpose/Concept - Separation of suspended solids by chemical coagulation, gravity settling, and filtration

B. Experiment 1 - Clarifier

1. Utilize recommended coagulant combination for clarification from jar tests conducted
2. Operate system at 10 gpm (400 gpd/ft^2)
3. Allow 8 hours to reach steady state
4. Check pH each hour to stabilize pH adjust system
5. Begin 24 hour experiment and collect composite sample from influent, effluent, and sludge to be sent to ATMI lab
6. Set sludge blowdown, record volume of sludge collected during 24 hours
7. Perform transmittance at dominant wavelength on effluent grab samples taken every 2 hours

    8. Perform TOC, pH transmittance, and color analysis on composite
    9. Record operating conditions and data on IBM data sheet

C. Experiment 1 - Filter

    1. Operate filter on clarifier effluent at 3 gpm (3 gpm/ft^2)
    2. Allow 3 backwash cycles to reach steady state during clarifier experiment 1 only
    3. Check influent and effluent transmittance and pressure every two hours on grab sample
    4. Backwash when transmittance or solids breakthrough occurs ($\geq$ 50% influent transmittance in effluent) or every 12 hours. Note pressure at breakthrough
    5. Begin collection of influent and effluent samples every 24 hours until 5 clarifier loading experiments are completed, send to ATMI lab
    6. Check influent and effluent transmittance every two hours on a grab sample
    7. Backwash when required per step C.4.
    8. Record time and duration of each backwash
    9. Perform TOC and color analyses on composite sample
    10. Record operating conditions and data on IBM data sheet

D. Experiment 2 - Clarifier

(Same as Experiment 1 - B.1 → a., except at 15 gpm)

E. Experiment 2 - Filter

(Same as Experiment 1, except backwash and begin at step C.5, and proceed to C.10.)

F. Experiment 3 - Clarifier

(Same as Experiment 1 - B.1 → 9, except at 20 gpm)

G. Experiment 3 - Filter

(Same as Experiment 2 - E.)

H. Experiment 4 - Clarifier

(Same as Experiment 1 - B.1 → 9, except at 25 gpm)

I. Experiment 4 - Filter

(Same as Experiment 2 - E.)

J. Experiment 5 - Clarifier

(Same as Experiment 1 - B.1. → 9., except at 30 gpm, 1200 gpd/ft^2)

K. Experiment 5 - Filter (Same as Experiment 2 - E.)

L. Experiment 6 - Clarifier

1. Operate clarifier at optimum coagulant dosage and less than the maximum flow found to be acceptable in Experiments 1 → 5 based on suspended solids removal
2. Continue operation following steps B.3. → 9.

M. Experiment 6 - Filter

1. Operate filter as per Experiment 2 - E., except at 5 gpm (5 gpm/ft^2)
2. Collect influent and effluent samples for 3 backwash cycles

N. Experiment 7 - Clarifier
(Same as Experiment 6 - L.1. → 2.)

O. Experiment 7 - Filter
(Same as Experiment 6 - M.1. → 2., except at 7 gpm, 7 gpm/ft^2)

III. Mode B

A. Purpose/Concept - Removal of suspended solids by straight filtration and removal of dissolved organics by carbon adsorption

B. Experiments 1, 2, and 3 - Filter
(Same as Mode A - Experiments 1, 6, and 7 -3,5, and 7 gpm/ft^2, finish carbon run at highest acceptable loading)

C. Experiment 1 - Carbon Columns

1. Operate columns on filter effluent at 45 min. empty bed HRT or 0.75 gpm
2. Backwash column #1 every day to prevent solids buildup due to biological growth. Backwash columns 2 and 3 at least twice per week
3. Collect grab samples every 4 hours after columns 1, 2, and 3 and perform TOC analyses
4. Collect composite influent and effluent samples every 24 hours and perform TOC and color analyses. Also send to ATMI Lab

D. Carbon column run can be terminated when column #1 has been exhausted, but run could be continued until end of the study at the site if desired.

IV. Mode C

A. Purpose/Concept - Removal of suspended solids by direct filtration of BPT effluent and removal of organics by oxidation with ozone.

B. Experiment 1 - Filter

(Same as Mode A - Experiment 1 - II.C.1. → 10.)

C. Experiment 1 - Ozone

1. Charge column with batch of wastewater to be ozonated.
2. Withdraw initial and final samples for analysis.
3. Calculate total mass of COD in reaction column in mg.
4. Select ozonation application rate such that total mass of ozone applied during a four-hour period is equal to 12 mg of ozone per mg of COD originally present in the column.
5. Begin ozonating at rate selected in 4 above. Collect samples of the off-gas in gas-wash bottles at 30 minute intervals, containing a KI solution. Titrate to determine O_3.
6. Collect samples of the water in the contactor at 20 minute intervals. Analyze for TOC and transmittance.
7. Calculate O_3 utilized by performing a mass balance on O_3. (O_3 utilized = O_3 applied - O_3 in off-gas)
8. Plot TOC and Color vs O_3:COD (or O_3:TOC or Time).
9. Plot O_3 utilized, TOC consumed and O_3 utilized/TOC consumed vs O_3:COD (or O_3:TOC or Time).

IV. Mode D

A. Purpose/Concept - Removal of organics from the wastewater by direct oxidation with ozone.

B. Experiment 1 - Ozone

(Same as Mode C)

V. Mode E

A. Purpose/Concept - This mode is an optional operating scheme which may be tested if it is desired to evaluate the ultimate treatment (full process train) of a particular waste. It can be performed during the last week or two weeks of the study at a given site. The optimum conditions for each unit process will be operated and the carbon columns will likely have to be re-charged.

Performance data in terms of ultimate effluent quality can be collected in this way.

VI. Mode F

A. Purpose/Concept - Removal of suspended solids from the waste by filtration, with pre-filter coagulation.

B. Experiment 1 - Filter

1. Utilize coagulant combination and dosage recommended for pre-filter use based on jar tests conducted in Atlanta Lab (I.B.1.g.)
2. Operate filter at 3 gpm (3gpm/ft^2)
3. Perform all operational and analytical steps listed in Mode A, Experiment 1 - C.1 → 10.

C. Experiment 2 - Filter

(Same as Mode F, Experiment 1 - B.1 → 3, except at 5 gpm, 5 gpm/ft^2)

D. Experiment 3 - Filter

(Same as Mode F, Experiment 1 - B.1 → 3, except at 7 gpm, 7 gpm/ft^2)

VII. Mode G

A. Purpose/Concept - Compare the effectiveness of dissolved air flotation (DAF) for removal of suspended solids with gravity settling.

B. Experiment 1 - DAF

1. Utilize coagulant combination and dosage recommended for pre-filter use based on the jar tests
2. Operate unit at 100% recycle using previous subnatant (effluent) as recycle
3. Pressurize to 40-50 psig for 10 minutes
4. Slowly and evenly allow pressurized recycle to enter flotation column
5. Record rise time for interface or slowest solids to float to the surface

6. Record volume of float at completion of test
7. Collect grab samples of influent and effluent to send to ATMI lab as well as for TOC and color analyses
8. Record operating conditions, TOC, and color analyses on IBM data sheet.

C. Experiment 2 - DAF

(Same as Mode G, Experiment 1 - B.1 → 8., except at 50% recycle)

D. Experiment 3 - DAF

(Same as Mode G, Experiment 1 - B.1 → 8, except at 33% recycle)

VIII. Mode H - Candidate Process Evaluation

A. Purpose/Concept - To evaluate the selected process trains which are most effective for treating the waste. Unit process operating conditions will be established based on screening experiments conducted at the site. The decision as to the unit processes making up these treatment trains will be made jointly by ES, EPA, and ATMI after approximately three weeks operation at a given site.

APPENDIX C

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APPENDIX C

SECTIONS FROM INDIVIDUAL PLANT REPORTS

PLANT A

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant A, a Subcategory I, Wool Scouring plant. The objectives of this pilot plant study are to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant A, determine the effectiveness of the technologies for achieving the BATEA guideline limitations and define the mutually (ATMI, EPA and ES) agreed upon recommendations for the most cost-effective treatment process(es).

Existing wastewater treatment facilities at Plant A include a grit chamber, aeration basin, secondary clarifier, chlorination and sludge drying beds. Additionally, pretreatment for grease removal includes a lanolin process. The experimental testing was performed on the secondary clarifier effluent.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations.

CONCLUSIONS

1. The existing wastewater facilities at Plant A were achieving the Best Practical Technology (BPT) guideline effluent limitations for all parameters during the period the pilot plant study was conducted.
2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations additional treatment beyond BPT is required to reduce TSS, COD and color.
3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant A.
   a. A wide variety of coagulants were evaluated through jar testing. A suitable coagulant or coagulant combination was not identified for use in reaction/clarification treatment of the BPT effluent. During jar testing none of the coagulants tested exhibited positive results for use as a pre-filter

coagulant. Based on the jar test results, reaction/clarification and multi-media filtration with pre-filter coagulation were not used during pilot plant experimentation.

b. Clarifier Followed by Multi-Media Filtration (Mode A) - The clarifier was operated at Plant A without coagulant addition due to the inability to identify a suitable coagulant. The clarifier was successful at removing 39% of the BPT TSS at the most effective loading (400 gpd/ft^2). The multi-media filter provided optimum removal of BOD, COD and TSS at a loading rate of 2 gpm/ft^2.

c. Clarifier Followed by Multi-Media Filtration Followed by Activated Carbon Adsorption (Mode H) - The multi-media filter was preceded by the clarifier due to the high BPT effluent TSS levels. At the optimum loading of 2 gpm/ft^2 the multi-media filter achieved 48% TSS and 12% COD removals, but was ineffective at reducing BOD$_5$ concentration in the clarifier effluent. The activated carbon columns successfully removed 78% BOD$_5$, 54% COD and 86% TSS from the multi-media filter effluent (averages for all filter loadings). Average effluent quality for Mode H at optimum operating conditions was 8 mg/l BOD$_5$, 365 mg/l COD and 11 mg/l TSS.

d. Clarifier Followed by Multi-Media Filtration Followed by Ozonation (Mode J) - Mode J batch experiments were done while the multi-media filter was being loaded at 3.0 - 3.7 gpm/ft^2. Ozone contactor influent TSS averaged 151 mg/l. Ozone dosages ranged from 32 to 709 mg/l utilized. Maximum COD reduction observed was 18%. Little or no BOD$_5$ removal was observed, but color reduction was indicated by an improvement in transmittance by 47%.

e. Dissolved Air Flotation (Mode G) - One dissolved air flotation experiment was run at 100% recycle with no coagulant addition. The DAF was not effective in BOD$_5$ removal and only minimally effective in removal of COD (12%), TSS (44%) and TOC (4%).

4. The three candidate BATEA process technologies for Plant A (those showing the greatest potential for favorable treatment effectiveness) are clarification followed by multi-media filtration (Mode A), clarification followed by multi-media filtration followed by carbon columns (Mode H) and clarification followed by multi-media filtration followed by ozonation (Mode J).

5. Of the three candidate process technologies tested, only Mode H was able to achieve all the BATEA guideline parameters. The projected effluent quality for Mode J exceeds the 30-day average BATEA guideline values for COD by 129 mg/l and TSS by 29 mg/l. It should be noted that due to equipment problems, Mode J process evaluation was based on 4 data points. The projected effluent quality for Mode A exceeds the 30-day average BATEA guideline values for COD by 146 mg/l, TSS by 28 mg/l and color by 26 ADMI units.

RECOMMENDATIONS

1. Clarification followed by multi-media filtration followed by granular carbon adsorption is the recommended BATEA process for Plant A. The projected effluent quality for this process will achieve all BATEA guideline values.

2. The recommended clarifier overflow rate is 400 gpd/ft^2. The multi-media filter surface loading rate should be 2 gpm/ft^2 followed by a carbon column hydraulic residence time of 45 minutes. The carbon loading capacity is 0.24 lb soluble COD/lb carbon. Process design criteria are presented in Chapter VI.

3. Additional efforts should be directed towards improving the quality of the secondary effluent before proceeding with development of the BATEA technology for "end-of-pipe treatment". Although effluent quality met BPT guideline values, more effective operation of BATEA candidate technologies could be achieved through optimization of BPT plant performance, particularly for TSS removal.

PLANT A

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the waste treatment plant effluent from the Plant A manufacturing facility, a Subcategory I Plant (Wool Scouring). The facility consists of scouring, carding and combing operations. The end product (wool top) is then used by wool finishing plants.

PRODUCTION DATA

The BATEA pilot plant was operated at this site for a 43-day period (Feb. 1, 1978 through March 15, 1978) during which the pilot plant was shut down on weekends. The production during this same 43-day period totaled 2,067,840 pounds of wool. During the days the plant was operating production averaged 68,928 pounds/day. The manufacturing plant has a maximum processing capacity of approximately 75,000 lbs/day (see Appendix E).

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant A is presented in Figure C-1(A). More specific process information is summarized in Table C-1(A).

The raw wastewater from the wool scouring facility is first pretreated by a process which includes lanolin grease removal and then passed through a grit chamber for removal of grit. It then enters the oxidation ditch. The volume of the oxidation ditch is 1.5 million gallons which provides a detention time of 76 hours. Aeration is provided by 4, 60 HP fixed mechanical surface aerators which provide a power to volume ratio of 160 HP/MG. Following aeration, the bio-solids are separated from the water in a 40 ft. diameter final clarifier. Sludge is returned to the aeration basin or may be wasted to sludge drying beds as required to maintain the desired concentration of suspended solids in the oxidation ditch. The clarified effluent is chlorinated prior to discharge into the receiving stream.

TABLE C-1(A)

PLANT A

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow - .47 MGD (approximately 5% sanitary waste)

Actual Flow During Study - 0.225 MGD

Equalization

None

Neutralization

None

Nutrient Addition

None

Screening

None

Grit Chamber

Oxidation Ditch

Basin Size - 1.5 MG

Aeration (Total) - 240 HP Total, 160 HP/MG

Detention Time - 76 hours at design flow, 160 hr. during study period

Secondary Clarifiers

No. of Clarifeirs - 1

Size:

- Diameter - 40 ft.
- SWD - 16 ft.
- Recycle Rate - .30 MGD (total)

Other Operations

Lanolin Grease Removal

Chlorination

Sludge Drying Beds

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data of the waste treatment plant, as reported by the plant, are shown in Appendix A for the one-year period immediately prior to and including the period of the pilot study. Daily operating data, as reported by the plant, are also presented in Appendix A for the period the pilot studies were in progress. The discharge values reported for the last year are compared to the BPT guideline values in Table C-2(A). The effluent values reported in this table are final effluent numbers. The pilot plant trailer operated on the secondary clarifier effluent prior to chlorination.

During the initial 15 days on-site the biological treatment plant was operating under upset conditions. Some unusual production and waste treatment plant operations that influenced the pilot plant operation are noted below:

- February 2-10: (1) Excessive aeration basin foaming contributed to solids carry-over in secondary clarifier. (TSS >1000 mg/1)

  (2) Low flows through treatment plant resulted in pilot plant shutdown. Grease and foam layer on surface of clarifier was removed manually each morning.
- February 9-10: Scouring line in production down.
- February 23: Clarifier upset.
- February 24-March 6: 50% of aerators down. Plant unable to waste sludge causing high inventory of solids in clarifier with resultant sludge blanket overflow.

Based on the monthly averages over a 12 month period (1977-1978) the plant is achieving 96% BOD_5 removal and 90% COD removal. During the same period, based on data presented in Table C-2(A) and Appendix E the plant was within all BPT guideline values except for two excursions on the 30-day average for TSS. The mean cell residence time ranges from approximately 4 to 30 days at this site.

WATER USAGE

Based on an average wastewater flow of 0.225 MGD during the on-site study, 3.3 gallons of wastewater were generated per pound of finished material produced.

TABLE C-2(A)

PLANT A

COMPARISON OF ACTUAL PERFORMANCE TO BPT GUIDELINE VALUES

	BPT Guideline Values				Actual Operation Feb. '77 - Jan. -78	
	lbs/day(1)		mg/1 at 0.26 MGD(2)		mg/1	
Parameter	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.	30-Day Avg.(3)	Max*
BOD_5	365	731	168	337	12-84(0)	16-260(0)
COD	4756	9512	2193	4387	465-1443(0)	550-1900(0)
TSS	1110	2219	512	1023	90-520(2)	150-970(0)
Oil & Grease	248	496	114	229	n.m.	n.m.
Phenol	3.45	6.90	1.59	3.18	0.003-0.024(0)	0.005-0.038(0)
Chromium	3.45	6.90	1.59	3.18	<0.030(0)	<0.030(0)
Sulfide	6.90	13.79	3.18	6.36	<0.1-<0.2(0)	<0.1-<0.2(0)
Flow, (MGD)	n.a.	n.a.	n.a.	n.a.	.130-.428	.257-.726
pH	(6.0 - 9.0)		(6.0 - 9.0)		7.7-8.1(0)	7.9-8.3(0)

(1) See Appendix E for the calculations of the BPT Guideline Values.

(2) Average flow for the period of February '77 through January '78 as reported by the plant.

(3) The figures in parentheses represent the number of months in the 12 month period in which the plant monthly averages or maximums exceed the BPT guidelines.

* These figures represent the range of the monthly average values as reported by the plant.

n.a. not applicable

n.m. not measured

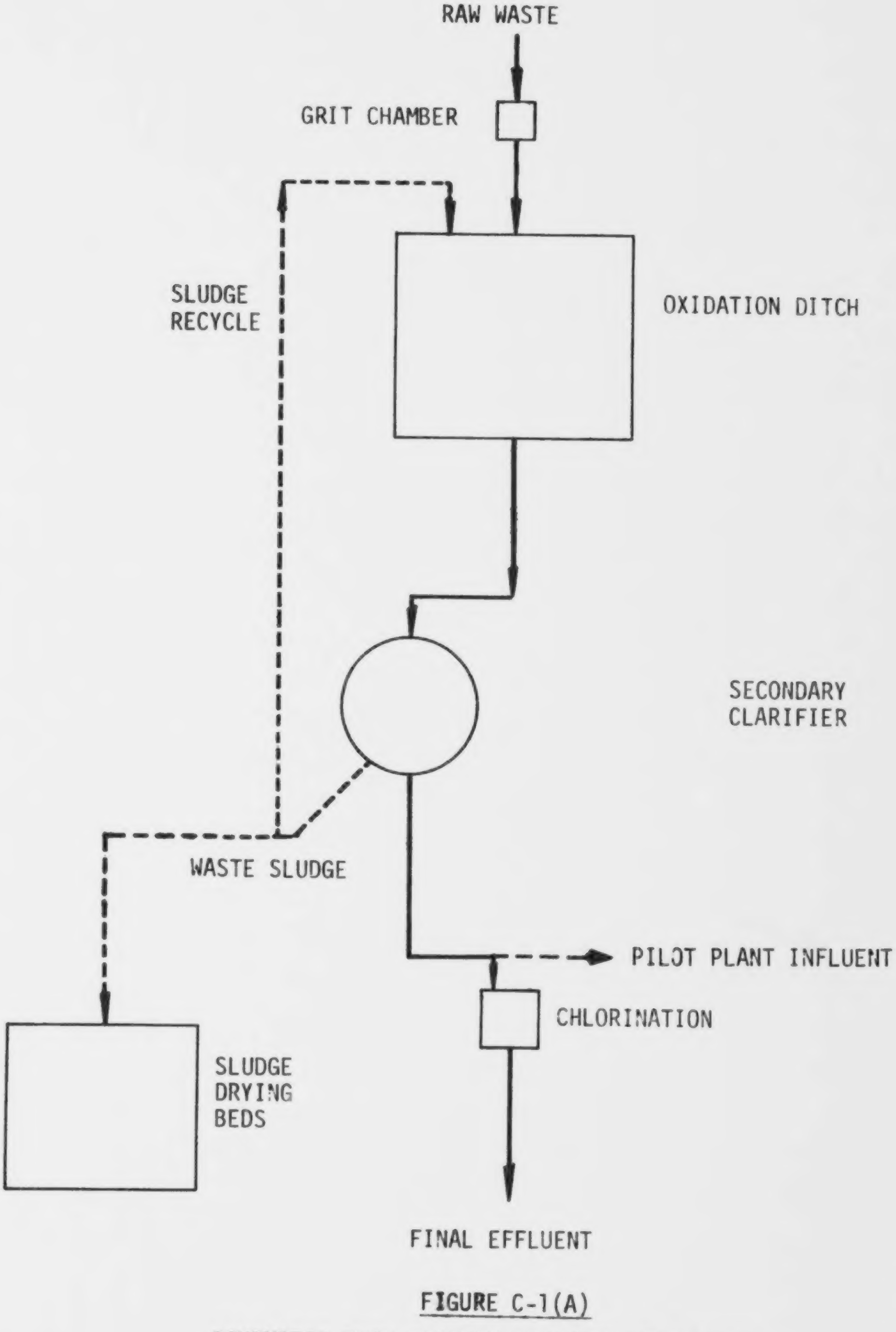

RAW WASTE
GRIT CHAMBER
SLUDGE RECYCLE
OXIDATION DITCH
SECONDARY CLARIFIER
WASTE SLUDGE
PILOT PLANT INFLUENT
CHLORINATION
SLUDGE DRYING BEDS
FINAL EFFLUENT

FIGURE C-1(A)

SCHEMATIC FLOW DIAGRAM-EXISTING WASTEWATER TREATMENT FACILITIES AT PLANT A

PLANT O

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant O, a Subcategory II, Wool Finishing and Subcategory VII, Stock and Yarn plant. The objectives of this pilot plant study are to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant O, determine the effectiveness of the technologies for achieving the BATEA guideline limitations and define the mutually (ATMI, EPA and ES) agreed upon recommendations for the most cost-effective treatment process(es).

Existing wastewater treatment facilities at Plant O include neutralization, vibrating screens, an aeration basin, a secondary clarifier and a sludge drying bed.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations.

CONCLUSIONS

1. The existing wastewater treatment facility at Plant O was not achieving the Best Practicable Technology (BPT) guideline effluent limitation for sulfide discharge during pilot plant operations.

2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations additional treatment beyond BPT is required to reduce COD, TSS, sulfide and chromium.

3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant O.

   a. Coagulation/Clarification Followed by Multi-Media Filtration (Mode A) - Jar tests indicated that 7 mg/l alum (as Al^{+3}) at a pH of 6.5 was the optimum coagulant dosage. Overflow rates from 300 to 1000 gpd/ft^2 were tested with various results due to significant variation in the BPT effluent data during the experiments. From the results of duplicate samples sent to the supporting laboratory it is known that at least part of the variability was due to poor analysis. Because of this it was difficult to select the optimum overflow rate. The multi-media filter operated best at 3.0 gpm/ft^2. Typical Mode A effluent quality at 400 gpd/ft^2 clarifier overflow rate followed by 3 gpm/ft^2 filter loading rate was 2 mg/l BOD$_5$, 72 mg/l COD and 9 mg/l TSS.

b. Multi-Media Filtration Followed by Carbon Adsorption (Mode B)

The optimum filter loading rate was found to be 3 gpm/ft^2. At this loading the filter provided a TSS level of 8 mg/l and COD concentration of 123 mg/l. Carbon columns following the filter were operated at 45 minutes hydraulic retention time utilizing virgin Westvaco WV-L granular carbon. COD reduction through the carbon columns averaged 77%. Typical Mode B effluent quality is 3 mg/l BOD$_5$, 45 mg/l COD and 6 mg/l TSS.

c. Multi-Media Filtration Followed by Ozonation (Mode C) - Initially two Mode C batch experiments were performed. Analytical results from the two tests were highly conflicting. The first experiment indicated a 16% COD reduction at 397 mg/l O_3 utilized while the second experiment indicated 95% COD reduction at 482 mg/l O_3 utilized. Additional batch experiments were done. Analytical results showed an average maximum COD reduction of 35% at 381 mg/l O_3 utilized. Ozonation increased average multi-media filter effluent BOD$_5$ from 4 to 12 mg/l. 52% average color removal was obtained through ozone contact.

d. Multi-Media Filtration with Precoagulation (Mode F) - Jar tests indicated that 2 mg/l alum (as Al^{+3}) with unadjusted pH was the lowest dosage to provide visual threshhold floc formation. The optimum loading rate for the filter was 3 gpm/ft^2 which provided an effluent TSS of 10 mg/l and COD of 185 mg/l. Filter performance was not enhanced by use of a pre-filter aid.

e. Dissolved Air Flotation (Mode G) - Four batch tests were performed at 100, 50 and 33 percent recycle using 7 mg/l alum (as Al^{+3}) at pH 6.5 as a coagulant. Extremely variable COD results were obtained showing 0 to 74 percent COD removal. During the screening period DAF performance was somewhat comparable to coagulation/clarification.

4. The two candidate BATEA process technologies for Plant O showing the greatest potential for favorable treatment effectiveness are Mode A, coagulation/clarification followed by multi-media filtration and Mode B, multi-media filtration followed by carbon adsorption.

5. Both candidate process technologies tested met the BATEA BOD_5, color and phenol guidelines. The average experimental values of Modes A and B met the TSS and COD limitations, however, the projected 90th percentile values of Mode A for both TSS and COD were outside the BATEA guideline values. Neither of the candidate processes met the BATEA guideline for sulfides.

RECOMMENDATIONS

1. Multi-media filtration followed by carbon adsorption is the recommended BATEA process for Plant O. The projected effluent quality for this process will achieve all BATEA guideline values except the guideline for sulfides.

2. The recommended filter loading is 3 gpm/ft^2. Carbon column hydraulic residence time should be 45 minutes. The carbon capacity is 0.23 pounds soluble COD per pound carbon. Process design criteria are presented in Chapter VI.

PLANT O

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the effluent from the wastewater treatment facility at Plant O. Production at Plant O is classified as both Subcategory II (Wool Finishing) and Subcategory VII (Stock and Yarn Dyeing and Finishing). During pilot plant operations wool finishing accounted for 65.7% of plant production while stock and yarn dyeing and finishing accounted for the remaining 34.3%. Plant O produces both 100% woolen and wool/nylon blends. Production processes include stock and piece dyeing, carbonizing and scouring.

PRODUCTION DATA

The BATEA pilot plant was operated at Plant O for a period of 39 days (July 10, 1978 through August 17, 1978). During this time Plant O operated for 31 days, averaging a production of 20,940 lb/day. Of the total production wool finishing accounted for an average 13,753 lb/day while stock and yarn dyeing and finishing accounted for 7,187 lb/day. (See Appendix E). Total production during pilot plant operations was 649,140 lbs of finished material. Fiber usage during this period was 74.5% wool and 25.5% wool/nylon blend. Predicted daily capacity for Plant O is 18,000 lb/day Stock and Yarn Dyeing and Finishing and 17,000 lb/day Wool Finishing.

Existing Waste Treatment Plant Description

A schematic flow diagram of the existing wastewater treatment facility at Plant O is given in Figure C-2(O). Specific process information is summarized in Table C-3(O).

Treatment plant influent is pumped from the textile mill elevation to the screening room elevation with a lift station located near the mill. Twenty-five percent caustic is introduced at the lift station for pH neutralization. Fibers are screened from the wastewater flow by two vibrating screens. Flow from the screening facility goes directly into the aeration basin. The basin has a volume of 1.25 MG and a design hydraulic detention time of 30 hours. Aeration is provided by 4 surface

TABLE C-3(O)

PLANT O

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow = 1 MGD

Normal Flow = 0.794 MGD

Flow During Pilot Plant Experimentation = 0.724 MGD

Equalization

None

Neutralization

Caustic Addition

Nutrient Addition

None

Screening

2-5' x 7', 60 mesh vibrating screens

Aeration Basin

No. of Basins - 1
Basin Size - 1.25 MG
Aeration - 100 HP (Surface aerators); 80 HP/MG
Detention Time- 30 hours (at Design Flow)
38 hours (at Normal Flow)
41 hours (during Pilot Plant Experiemntation)

Secondary Clarifiers

No. of Clarifiers - 1
Size: Diameter - 55'
Side Water Depth - 13'
Recycle Rate - 50%

Other Operations

30' x 30' Sludge Drying Bed
(not used on a regular basis)

aerators at a power/volume ratio of 80 HP/MG. From the aeration basin the stream flows to the secondary clarifier. Design clarifier surface loading is 421 gpd/ft^2. Underflow from the secondary clarifier is returned to the aeration basin at a rate that corresponds to 50% of the treated flow. There is a sludge drying bed at the Plant O wastewater treatment facility, but it is not used on a regular basis due to the extensive time required to dry sludge.

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

Appendix A shows the monthly operating data for the Plant O wastewater treatment facility as reported by plant personnel. This data covers a one year period immediately prior to and including the period of pilot unit operations. The discharge values reported for the last year are compared to the Best Practical Treatment (BPT) Guideline values in Table C-4(O). The effluent values reported in this table are final effluent numbers.

Based on the monthly averages over a twelve month period (July 1977 to June 1978) the plant was achieving approximately 90% BOD_5 removal from an average influent of 333 mg/l to 31 mg/l and 61% COD removal from an average influent of 529 mg/l to an effluent of 209 mg/l. During the same twelve month period, based on the data presented in Table C-4(O) Appendix E, the plant exceeded the BPT 30-day average guideline for BOD_5 six times, for COD three times, for TSS nine times and four times for chromium.

Operational problems and changes that affected pilot plant operations while on-site at Plant O included the following.

(1) 400 gallons of 0.1% medium cationic polymer was added to the aeration basin on July 13 and 15, 1978 (800 gallons total).

(2) From the time that pilot operations began through July 17, 1978 only 3 of 4 aerators in the aeration basin were in operation. On the morning of July 18, 1978 the 4th was put back into service.

TABLE C-4(O)

PLANT O

COMPARISON OF ACTUAL PERFORMANCE WITH BPT GUIDELINE VALUES

	BPT Guideline Values				Actual Operation(4) July '77 - June '78 mg/l			
	lbs/day1)		mg/l at 0.794 MGD2)					
PARAMETER	30-DAY AVG.	DAILY MAX.	30-DAY AVG.	DAILY MAX.	30-DAY AVG.(3)		DAILY MAX.* (3)	
BOD$_5$	178	357	27	54	4 - 172	(6)	8 - 172	(6)
COD	1425	2850	215	430	54 - 423	(3)	54 - 510	(1)
TSS	305	609	46	92	32 - 197	(9)	41 - 898	(9)
Phenol	1.39	2.79	0.21	0.42	0.02 - 0.031	(0)	0.02 - 0.031	(0)
Chromium	1.39	2.79	0.21	0.42	.165 - .982	(3)	.165 - 1.19	(2)
Sulfide	2.79	5.58	0.42	0.84	n.m.		n.m.	
Flow, (MGD)	n.a.	n.a.	n.a.	n.a.	.63 - 1.089		.71 - 1.252	
pH (units)	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0	6.0 - 7.4	(0)	6.6 - 11.3	(1)

(1) See Appendix E for the calculations of the BPT Guideline Values.

(2) Average flow for the period of July '77 through June '78 as reported by the plant.

(3) The figures in parentheses represent the number of months in the 12-month period in which the plant monthly averages or maximums exceed the BPT Guidelines.

(4) Based on 0 to 6 samples per month except TSS (4 to 15 samples/month).

* These figures represent the range of monthly maximum values as reported by the plant.

n.a.- not applicable.

n.m.- not measured because this is not a permitted parameter. Data collected during pilot plant operation indicated an average sulfide value greater than the BPT guideline limitation.

(3) On July 28, 1978 a flow equalization valve was installed between the aeration unit and the secondary clarifier. This occurrence affected pilot plant operations in two ways:

a) Plant discharge flow was retained in the aeration basin for 16 hours; thus stopping pilot plant operation.

b) Clarifier loading was equalized after valve installation. The result should have been overall better clarifier performance.

(4) Heavy rains during the night of July 7, 1978 caused the storm sewer at Plant O to be overloaded. The hydraulic shock caused the aeration basin to overflow. Operators applied full hydraulic loading to the secondary clarifier in an attempt to stop the flooding.

(5) Plant O was shut down for a period of ten days just prior to the beginning of trailer operations. Treatment plant effluent could have been affected during the first several days of experimentation.

TREATMENT PLANT INFLUENT VARIABILITY

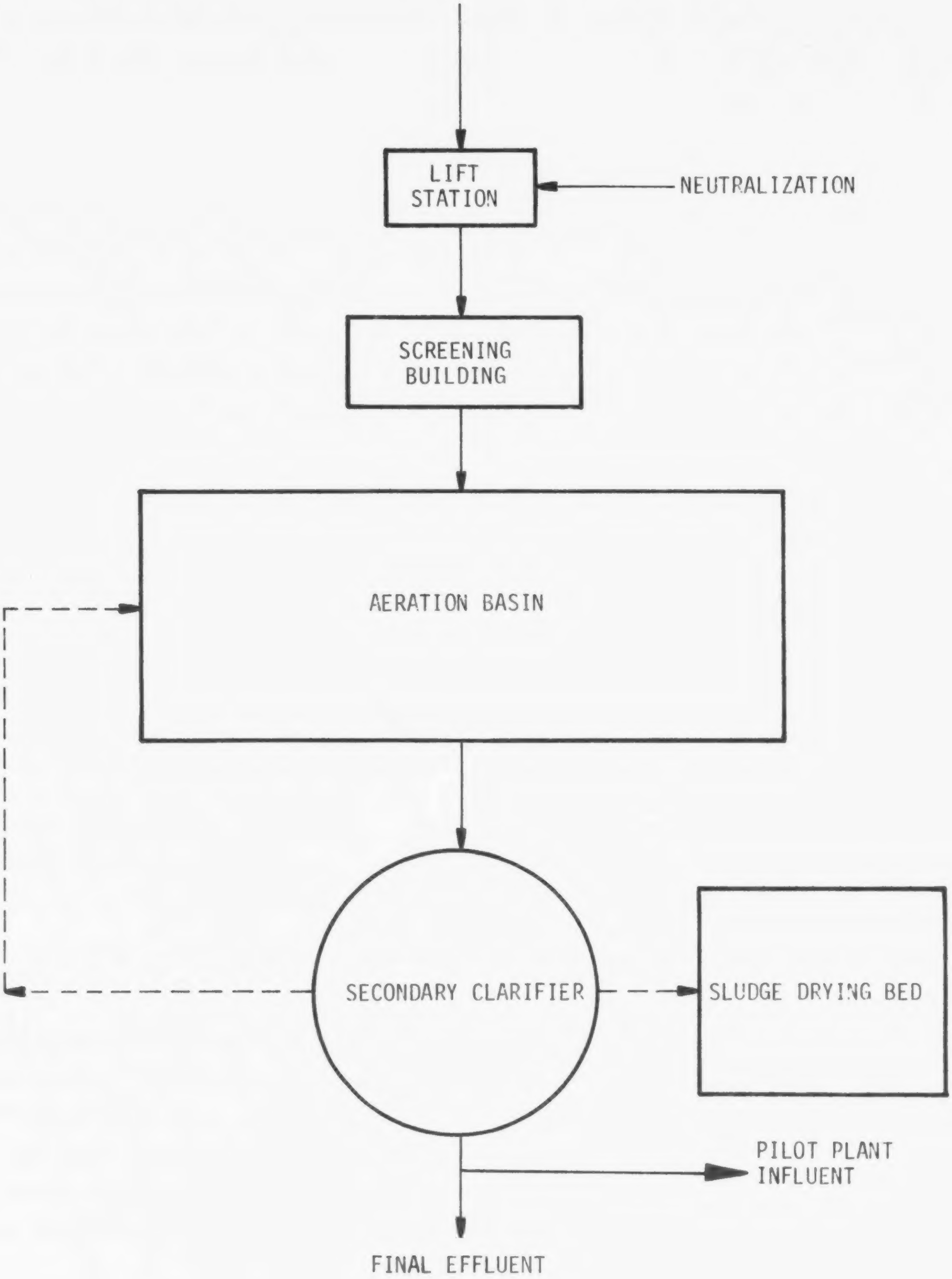
During pilot plant operations the textile manufacturing plant generally operated 5 to 6 days per week. Weekend shut down caused periods of no discharge. The plant was shut down from July 1 through July 9 for the holidays. The trailer started operation on July 10 so the first several days waste stream may not have been representative.

WATER USAGE

Based on an average wastewater flow of 0.724 MGD during pilot plant operations, 34.6 gallons of water were used per pound of finished material.

FIGURE C-2(O)

SCHEMATIC DIAGRAM - EXISTING WASTEWATER TREATMENT FACILITIES AT PLANT O


LIFT STATION
NEUTRALIZATION
SCREENING BUILDING
AERATION BASIN
SECONDARY CLARIFIER
SLUDGE DRYING BED
PILOT PLANT INFLUENT
FINAL EFFLUENT

PLANT B

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant B, a subcategory II, wool finishing, plant. The objectives of this pilot plant study were to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant B, determining the effectiveness of the technologies for achieving the BATEA guideline limitations, and the mutually (ATMI, EPA and ES) agreed recommendations for the most cost-effective treatment process.

Existing wastewater treatment facilities at Plant B include screens, equalization, aeration, secondary clarification, chlorination and dissolved air flotation and vacuum filtration for sludge dewatering. The experimental testing was performed on the secondary clarifier effluent prior to chlorination.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations:

CONCLUSIONS

1. The existing wastewater facilities at Plant B were not achieving the Best Practical Technology (BPT) guideline effluent limitations for BOD_5, COD or TSS during the period the pilot plant study was conducted.
2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations additional treatment beyond BPT is required to reduce BOD_5, COD, TSS, chromium and color.
3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant B.
    a. Coagulation/Clarification followed by Multi-Media Filtration (Mode A) - The reactor/clarifier effectively reduced BOD_5, COD TSS, color, chromium, phenol and sulfides from the BPT effluent. The TSS reduction ranged between 94 and 99 percent and the BOD and COD reduction ranged between 75 and 89 percent during favorable operating conditions. The optimum coagulant

dosage was alum at 35 mg/l as Al^{+3} with lime as a weighing agent and for pH control at about 100 mg/l $Ca(OH)_2$. The optimum pH was determined to be between 6.5 and 7.0 and the most effective performance was observed at an overflow rate of 400 gpd/ft^2. Because of the quantity and the thickening characteristics of the lime/alum sludge, an underflow of 25 percent of the influent was required to maintain a constant sludge blanket in the clarifier. The multi-media filter provided additional removal of BOD_5, COD and TSS and operated effectively at a surface loading rate of 7 gpm/ft.

b. Multi-Media Filtration Followed by Activated Carbon Adsorption (Mode B) - The TSS concentration of the BPT effluent was too high to allow effective operation of multi-media filter. At loadings as low as 0.5 gpm/ft^2 effluent solids reached 112 mg/l. Activated carbon achieved 59 and 72 percent removal of applied BOD and COD. The carbon columns also reduced TSS, TOC, color, phenol, sulfide and chromium.

c. Multi-Media Filtration Followed by Ozonation (Mode C) - The multi-media filter was not effective because of high TSS values as discussed in Conclusion 2b. Ozone reduced COD and color by a small amount, but was not effective for reduction of other parameters.

d. Ozonation (Mode D) - As in Mode C experiment ozone demonstrated the ability to reduce small amounts of COD and color.

e. Multi-Media Filtration with Precoagulation (Mode F) - The multi-media filter operated with alum at 30 mg/l (Al^{+3}) as a precoagulant was not an effective process. The filter provided reduction of BOD_5, COD and TSS, but filter run times were extremely short and effluent TSS values ranged from 39 to 252 mg/l.

f. Dissolved Air Flotation (Mode G) - The bench-scale dissolved air flotation (DAF) experiment demonstrated effective removals of all parameters using 20 mg/l alum (Al^{+3}) as a coagulant. The DAF process may be considered an alternative to the coagulation clarification process and warrents further experimental evaluation.

4. The three candidate BATEA process technologies (those showing the greatest potential for favorable treatment effectiveness) for Plant B are reactor/clarifier followed by multi-media filter (Mode A), Mode A followed by carbon columns (Mode H) and Mode A followed by ozonation (Mode I).

5. Mode H was the only candidate process technology tested that clearly achieved a projected effluent quality that would meet all the BATEA effluent guideline values at Plant B. Mode A achieved all the BATEA guideline values except for BOD_5. The BATEA guideline value for BOD_5 was 38 mg/l and the projected BOD_5 value for Mode A was 39 mg/l. Mode I did not achieve the BATEA guideline values for BOD_5 or COD.

6. Comparative capital cost and operating and maintenance cost indicate that Mode A is significantly less expensive than Mode H.

RECOMMENDATIONS

1. Coagulation clarification followed by multi-media filtration is the recommended BATEA process for Plant B. The projected effluent quality for this process will achieve the BATEA guideline values except for the BOD_5 concentration which exceeds the BATEA guideline value of 38 mg/l by 1 mg/l.

2. The recommended overflow rate for the reactor clarifier is 400 gpd/ft^2 and the recommended chemicals are alum for coagulant at 35 mg/l as Al^{+3} and lime at 100 mg/l as $Ca(OH)_2$ to act as a weighting agent and to adjust the pH between 6.5 and 7.0. The recommended surface loading for the multi-media filter is 7 gpm/ft^2. Process design criteria are presented in Chapter VI.

3. An engineering and operational evaluation of the existing wastewater treatment system at Plant B is recommended before proceeding with the development of BATEA technology for end-of-pipe treatment. The present effluent did not meet the BPT guideline limitations for BOD_5, COD and TSS during the pilot plant study.

PLANT B

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the waste treatment plant effluent from the Plant B manufacturing facility, a Subcategory II (Wool Finishing) Plant. This plant is involved in manufacturing and finishing wool and blended wool fabrics. The primary fibers used are wool and cotton. An important feature of this plant is that a large percentage of the wool is recycled from recycled woolen goods.

PRODUCTION DATA

The BATEA pilot plant was operated for a 51-day period (August 2, 1977 thru September 21, 1977) at this site. The production during this same 51-day period totaled 2,959,526 pounds of material. The production during the days the manufacturing plant was in operation (44 days) averaged 67,262 pounds/day (see letter in Appendix E). Production averaged 70% wool fabrics and 30% cotton/synthetic blends. The manufacturing plant has a capacity of approximately 75,000 pounds per day of all fabrics and fabric blends.

EXISTING WASTE TREATMENT PLANT DESCRIPTION

The schematic flow diagram of the existing wastewater treatment facilities at Plant B is presented in Figure C-3(B). The raw wastewater includes sanitary waste from the mill, which is less than 1% by volume of the total flow. The raw wastewater is first treated by vibratory fine screens (0.007 inch) that remove solid materials. The screenings are trucked to a land fill each day. The waste flows into an aerated equalization basin (250,000 gallon capacity), then, in a step-feed arrangement into parallel aeration basins (600,000 gallon capacity each). The total detention time in the aeration basins at the design flow of 1.2 MGD is 24 hours. Aeration is provided by floating aerators at a power to volume ratio of 133 HP/MG. Following aeration, the bio-solids are separated from the water by two parallel final clarifiers. The waste sludge is thickened by dissolved air flotation (DAF) dewatered by vacuum filtration and then landfilled. The average sludge age is approximately 65 days. The supernatant from the secondary clarifiers is chlorinated and discharged. The waste treatment plant process design criteria are summarized in Table C-5(B).

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data of the waste treatment plant, as reported by the plant, are shown in Appendix A for the twelve-month period immediately prior to and including the period of the pilot study. Daily operating data, as reported by the plant, are also presented in Appendix A for the period the pilot studies were in progress. The discharge values reported for this period are compared to the BPT guideline values in Table C-6(B). The effluent values reported in this table are final (after chlorination) effluent numbers. The pilot plant trailer operated on the secondary clarifier effluent immediately prior to chlorination.

Based on the plant reported data presented in Appendix A and in Table C-6(B), the waste treatment plant is within BPT guideline values for 30-day averages and daily maximums for COD and TSS. The plant meets the daily maximum BOD_5 guideline and is within 13% of the 30-day average guideline for BOD_5. Historical data on phenols, total chromium, sulfides and color were not monitored by the waste treatment laboratory.

During the on-site experimental study, there were several pilot plant operational problems associated with the BPT plant operation.

- Both the COD and TSS influent to the pilot plant varied significantly. This created high solids loadings on the multi-media filter and hindered its operation. Also massive sludge volumes were produced in the reactor/clarifier resulting in sludge thickening problems. Figure C-4(B) shows the variation of both TSS and COD with time during the screening experiments. The TSS and COD values reported in Figure C-4(B) are for the pilot plant influent composite samples. These values are greater than the BPT effluent values reported by the plant.
- The mill was in production Monday thru Friday and shut down on the weekends. The waste treatment plant had no flow during the shut down periods.

TABLE C-5(B)

PLANT B

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow - 1.2 MGD

Equalization

No. of Basins - 1
Basin Size - 0.25 MG
Detention Time - 5 hours
Aerated - 15 HP; 60 HP/MG

Neutralization

None

Nutrient Addition

Phosphorous (Intermittently added)

Screening

Fine Screens - 0.007 inch

Aeration Basin

No. of Basins - 6
Volume (Total) - 1.2 MG
Aeration (Total) - 160 HP; 133 HP/MG
Detention Time - 24 hours

Secondary Clarifiers

No. of Clarifiers - 2
Size: Diameter - 40 ft (inside diameter)
Side Water Depth 12 ft
Recycled Rate - 1.0 MGD (total)

Disinfection

Chlorination - 1

Sludge Disposal

Thickening - dissolved air flotation
Dewatering - vacuum filtration
Ultimate - landfill

TABLE C-6(B)

PLANT B

COMPARISON OF ACTUAL PERFORMANCE WITH BPT GUIDELINE VALUES

Parameter	BPT Guideline Values lbs/day 1) 30-Day Avg.	BPT Guideline Values lbs/day 1) Daily Max.	BPT Guideline Values mg/l at 0.93 MGD 2) 30-Day Avg.	BPT Guideline Values mg/l at 0.93 MGD 2) Daily Max.	Actual Effluent 4) Oct 76 thru Sept 77 mg/l Monthly Avg.	Actual Effluent 4) Oct 76 thru Sept 77 mg/l Monthly Max.
BOD_5	753	1507	97	194	110	122
COD	5482	10,964	707	1414	605 3)	688 3)
TSS	1184	2368	153	305	96	130
Phenol	4.71	9.42	0.61	1.21	n.m.	n.m.
Chromium	4.71	9.42	0.61	1.21	n.m.	n.m.
Sulfide	9.42	18.83	1.21	2.43	n.m.	n.m.
Color	n.a.	n.a.	n.a.	n.a.	n.m.	n.m.
Flow	n.a.	n.a.	n.a.	n.a.	0.93	3.3
pH	(Within the range of 6.0 to 9.0)				7.1	-

1) See Appendix E for the calculations of the BPT Guideline Values.

2) The average flow for the period of October 1976 to September 1977 was reported by the plant as 0.93 MGD.

3) Data from last three months only.

4) Plant reported data from Appendix A.

n.m.-Parameters not monitored by mill laboratory.

n.a.-not applicable.

WATER USAGE

Based on an average wastewater flow of 0.98 MGD during the on-site study, 14.6 gallons of wastewater was generated per pound of finished material produced.

FIGURE C-3(B)

SCHEMATIC FLOW DIAGRAM - EXISTING WASTEWATER TREATMENT PLANT AT PLANT B

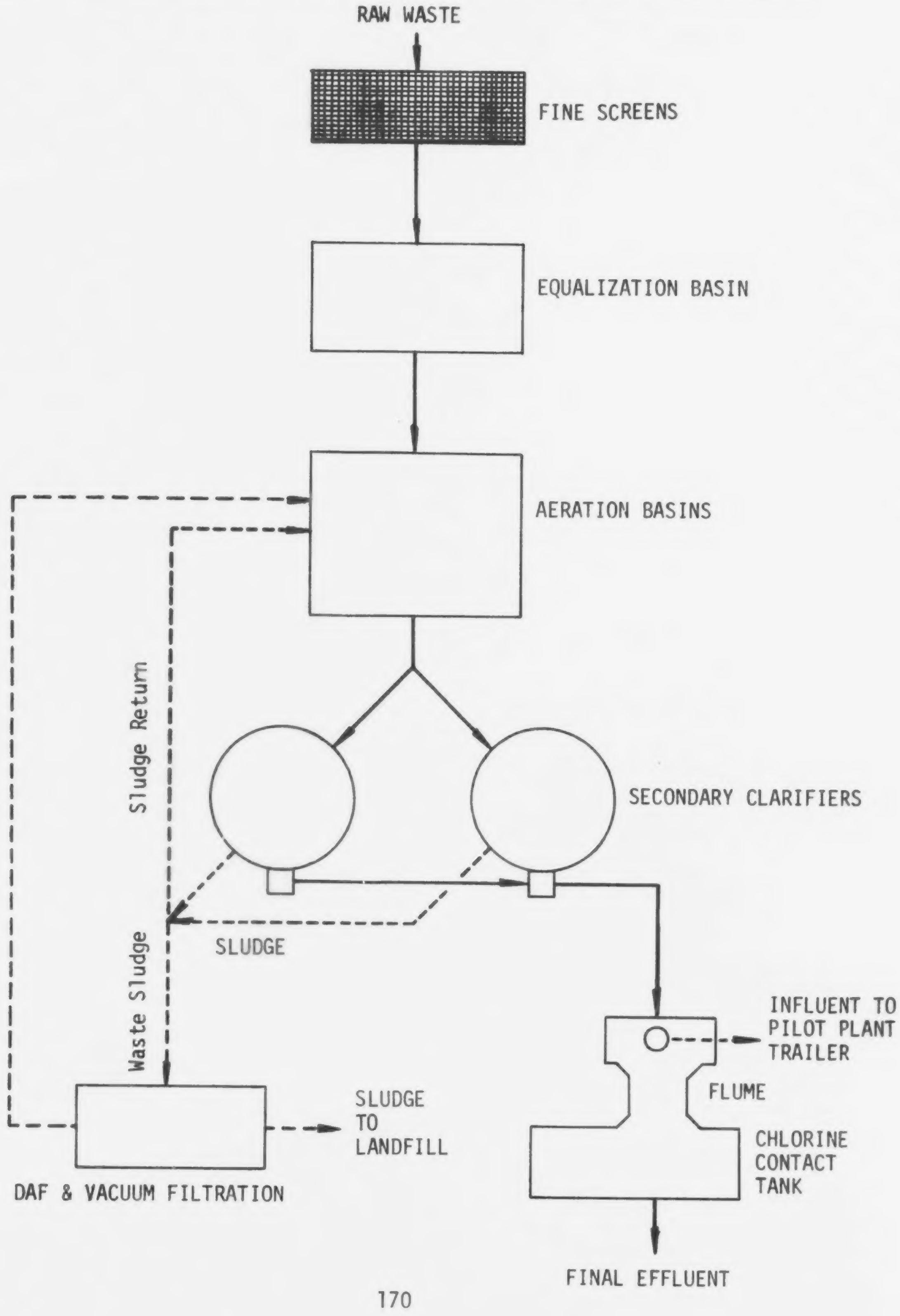
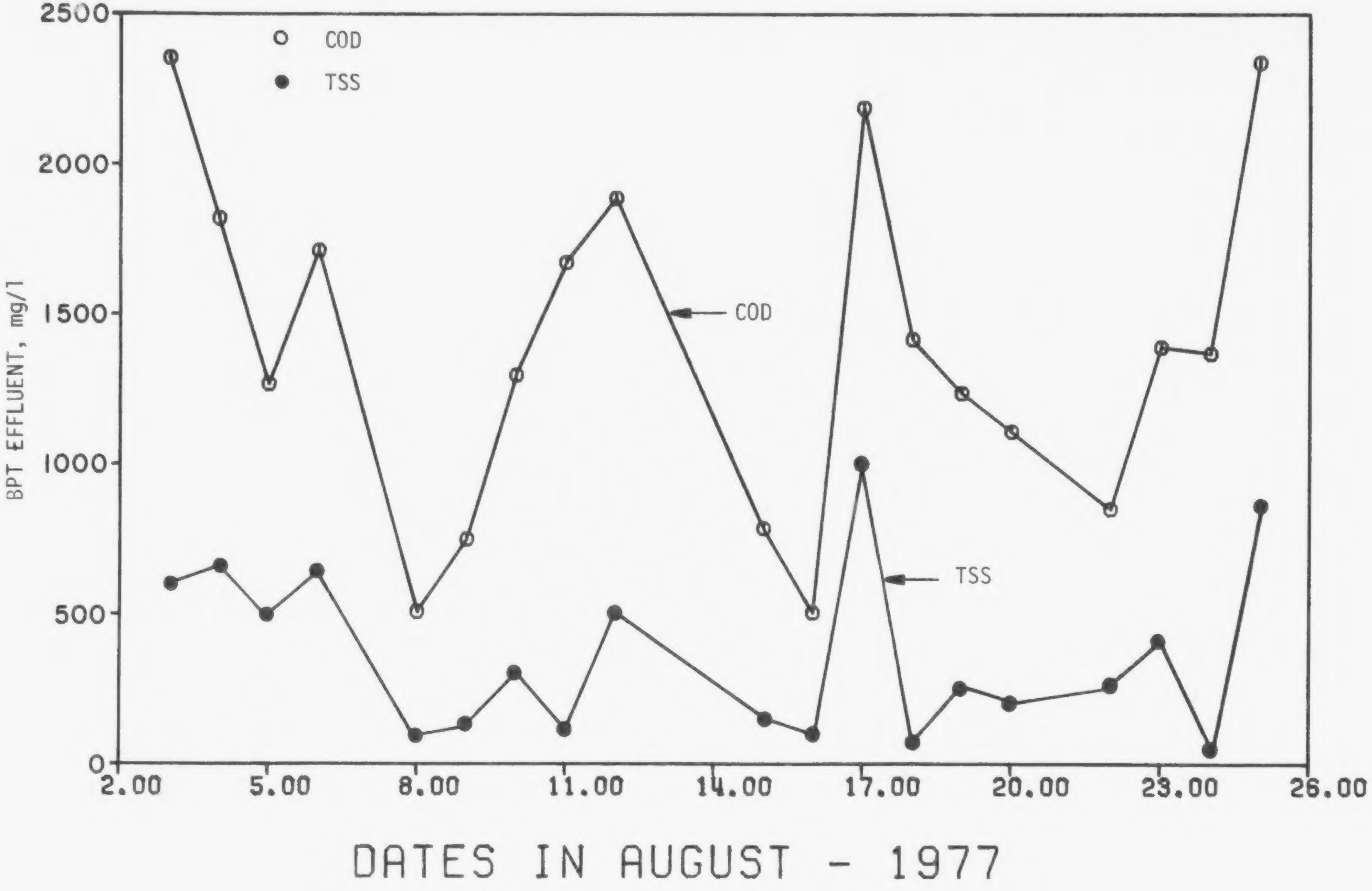

RAW WASTE
FINE SCREENS
EQUALIZATION BASIN
AERATION BASINS
Sludge Return
SECONDARY CLARIFIERS
SLUDGE
Waste Sludge
INFLUENT TO PILOT PLANT TRAILER
FLUME
CHLORINE CONTACT TANK
SLUDGE TO LANDFILL
DAF & VACUUM FILTRATION
FINAL EFFLUENT

FIGURE C-4(B)

PLANT B

VARIATION OF BPT EFFLUENT



PLANT D

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant D, a Subcategory D (IV) Woven Fabric Finishing Plant. The objectives of this pilot plant study were to evaluate the potential BATEA technologies for treating the BPT effluent of Plant D, determine the effectiveness of the technologies for meeting the BATEA effluent limitations, and define the mutually (ATMI, EPA and ES) agreed upon recommendation for the most cost-effective treatment process(es).

Existing wastewater treatment facilities at Plant D include screening, neutralization, aeration, secondary clarification, chlorination and sludge storage. The experimental testing was performed on the secondary clarifier effluent prior to chlorination.

The information generated during the study and presented in this report forms the basis for the following conclusions and recommendations:

CONCLUSIONS

1. The existing wastewater treatment facilities at Plant D were not achieving the Best Practical Technology (BPT) guideline limitations for COD or TSS during the period the pilot plant study was conducted.
2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations, additional treatment beyond BPT is required to reduce the COD, TSS and color.
3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant D:
    a. Coagulation/Clarification Followed By Multi-Media Filtration (Mode A) - Extensive jar tests were conducted in which alum at 150 mg/l as Al^{+3} with lime at 200 mg/l were the only coagulants identified that could partially be effecting the TSS reduction. However, it was not possible to operate the coagulant feed system and the reactor/clarifier in the pilot

unit at these high dosages. Therefore, no Mode A experiments were conducted at this site.

b. Multi-Media Filtration Followed by Activated Carbon Adsorption (Mode B) - The multi-media filter removed 90 to 95 percent of the TSS at loadings of 2.0 to 2.5 gpm/ft^2. At greater loadings the TSS removal efficiency generally decreased. The filter also removed some BOD_5, COD, and TOC. The carbon columns were marginally effective for organic reduction (COD reduced 13 to 59 percent and TOC reduced 30 to 38 percent) but did not reduce much of the color.

c. Multi-Media Filtration Followed by Ozonation (Mode C) - The multi-media filter did not perform as well in Mode C as in Mode B. The percent removal of TSS was lower than observed in Mode B and the reduction of BOD_5, COD, and TOC was negligible. Ozonation provided organic reduction based on COD of 50 to 62 percent and also provided color reduction. However, ozone dosages of 225 to 1183 mg/l utilized were required.

d. Ozonation (Mode D) - Direct ozonation of the BPT effluent was not an effective treatment process because of the high TSS concentration. At dosages above 400 mg/l ozone utilized, 80 percent of the color was removed. Approximately 50 percent reduction of COD could be achieved at impractical ozone dosages above 1200 mg/l utilized.

e. Multi-Media Filtration with Precoagulation (Mode F) - The multi-media filter operated with 10 mg/l alum (as Al^{+3}) provided TSS removals of less than 42 percent and COD removals of less than 13 percent.

f. Dissolved Air Flotation (Mode G) - The dissolved air flotation experiment demonstrated some reduction of COD, TSS, color and sulfide and practically no reduction of BOD_5, TOC, and phenol. The DAF process may be considered an alternative process to coagulation clarification.

4. The two candidate BATEA process technologies (those showing the greatest potential for favorable treatment effectiveness) for Plant D are multi-media filtration followed by carbon columns (Mode B) and Mode B followed by ozonation (Mode H).

5. Neither candidate process technology tested could achieve all BATEA guideline parameters. The projected effluent quality from Mode B exceeds the 30-day average BATEA guideline values for COD by 251 mg/l and color by 638 ADMI units. The projected effluent quality from Mode H exceeds the 30-day average BATEA guideline values for BOD by 6 mg/l, COD by 174 mg/l and color by 51 ADMI units. The overall effluent quality of Mode H was better than Mode B.

RECOMMENDATIONS

1. Multi-media filtration followed by carbon columns, followed by ozonation is the recommended BATEA process for Plant D. The projected effluent does not achieve the BATEA guideline values for BOD_5, COD or color. Due to operational problems with the waste treatment plant BPT effluent quality was not achieved with the existing waste treatment plant. If BPT quality were achieved a different BATEA process train may be appropriate.

2. The recommended surface loading rate for the multi-media filter is 2 gpm/ft^2. The recommended empty bed hydraulic retention time for the carbon columns is 45 minutes and the range of ozone dosage should be 350 to 400 mg/l utilized. The carbon capacity is 0.042 gm TOC/gm carbon. Process design criteria are presented in Chapter VI.

3. Additional efforts should be directed towards improving the quality of the secondary effluent before proceeding with development of the BATEA technology for "end of pipe treatment". The present effluent does not meet the BPT guideline limitations.

PLANT D

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the waste treatment plant effluent of the Plant D textile manufacturing facility, a Subcategory IV (Woven Fabric Finishing) Plant. This plant is involved in simple and complex manufacturing operations of natural, synthetic and blends of natural and synthetic fibers. The division between simple and complex operations is approximately 85% and 15%, respectively. The primary fibers used are cotton, polyester and rayon. The production processing operations include PVA desizing, bleaching, dyeing (continuous) and special finishes (mildew and water repellents).

PRODUCTION DATA

The BATEA pilot plant was operated for a 43-day period (September 26, 1977 through November 7, 1977) at this site. The production during this same 43-day period totaled 2,110,050 pounds of material. The production during the days the plant was operating averaged 70,335 pounds/day (see letter in Appendix E). Materials included 100% cotton, cotton/polyester blends, cotton/rayon blends and 100% polyester. The manufacturing plant has a capacity of approximately 125,000 pounds per day.

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant D is presented in Figure C-5(D). More specific process infomation is summarized in Table C-7(D). The treated wastewater included the industrial waste plus sanitary waste from one shift of plant employees. The raw wastewater passes through a bar screen, then acid is added into the waste stream for neutralization prior to entering the neutralization basin. Following neutralization two aeration basins are operated in series with a total volume of 2.4 million gallons at a detention time of 38 hours. Aeration is provided by surface aerators at a power to volume ratio of 125 HP/MG. Following aeration, the bio-solids are separated from the water by two final clarifiers in series. The sludge from the clarifiers

TABLE C-7(D)

PLANT D

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow - 1.5 MGD

Equalization

None

Neutralization

Acid feed prior to Neutralization Basin

No. of Basins - 1

Basin Size - 18,510 gallons

Detention Time - 18 mins. (at design flow)

Mixing - 5 HP

Nutrient Addition

None

Screening

Bar Screens - 1 in.

Fine Screens - 0.030 in.

Aeration Basin

No. of Basins - 2 (in series)

Volume (Total) - 2.4 MG

Aeration (Total) - 300 HP; 125 HP/MG

Detention Time - 38 hrs (at design flow)

Secondary Clarifiers

No. of Clarifiers - 2 (in series)

Size: Diameter - 60 ft (inside diameter)

Side Water Depth - 11 ft

Recycle Rate - 3.3 MGD (total)

Other Facilities

Chlorination

Aerated sludge holding tank

is either returned to the aeration basins or held in an aerated holding tank. The supernatant from the secondary clarifiers is chlorinated and discharged.

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data, of the waste treatment plant as reported by the plant, are shown in Appendix A for the one-year period immediately prior to and including the period of the pilot study. Daily operating data, as reported by the plant, are also presented in Appendix A for the period the pilot studies were in progress. The discharge values reported for the last year are compared to the BPT guideline values in Table C-8(D). The effluent values reported in this table are final effluent numbers. The pilot plant trailer was operated with the secondary clarifier effluent prior to chlorination.

Based on the data presented in Appendix A and in Table C-8(D), the waste treatment plant was within BPT guideline values for 30-day averages and daily maximums for BOD_5, phenol and chromium. For TSS the waste treatment met the 30-day average but exceeded the daily maximum limitation. The COD from the waste treatment exceeded both the 30-day average and the daily maximum limitation. Sulfide values were not reported by the plant.

During the on-site experimental study there were several major effluent quality upsets created by production changes or biological treatment operations. A three day period (November 3 through 5, 1977) of clarifier upset during the candidate mode operation required the use of the clarifier ahead of the filters. The TSS concentration of the BPT effluent was high during another three day period (October 3 through 5, 1977) when one of the two secondary clarifiers was taken out of service for mechanical repairs. Plant production facilities were shutdown each weekend although the waste treatment plant continued to operate.

WATER USAGE

Based on an average wastewater flow of 0.41 MGD during the on-site study, 5.8 gallons of wastewater were generated per pound of finished material produced.

TABLE C-8(D)

PLANT D

COMPARISON OF ACTUAL PERFORMANCE WITH BPT GUIDELINE VALUES

Parameter	BPT Guideline Values				Actual Operation Nov. '76 - Oct. '77	
	lbs/day		mg/1 at 0.33 MGD(2)		mg/1	
	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.	Avg.	Max.
BOD_5	233	464	85	169	38	98
COD	2290	4579	832	1664	899	1943
TSS	626	1252	227	455	177	749
Phenol	3.5	7.0	1.27	2.54	.02	0.09
Chromium	3.5	7.0	1.27	2.54	< .02	0.02
Sulfide	7.0	14.1	2.54	5.09	n.m.	n.m.
Flow	n.a.	n.a.	n.a.	n.a.	(.33 MGD)	(.74 MGD)
pH	Within The Range 6.0 to 9.0				(5.8 to 8.6)	

(1) See Appendix E for the calculations of the BPT Guideline values.

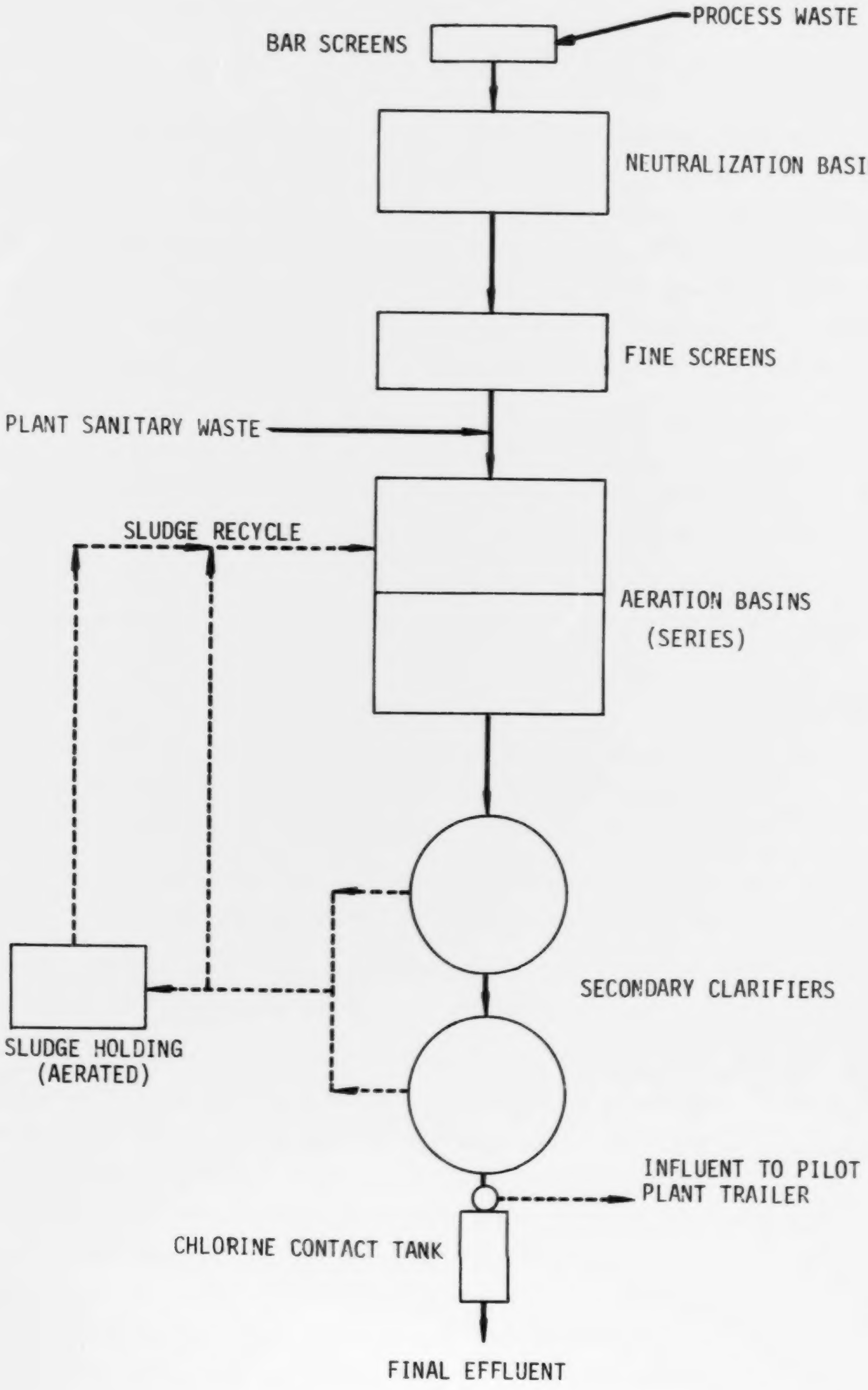
(2) The average flow for the period November 1976 through October 1977 was reported by the plant as 0.33 MCD.

n.m.-not monitored by plant laboratory

n.a.-not applicable

FIGURE C-5(D)

SCHEMATIC FLOW DIAGRAM - EXISTING WASTEWATER TREATMENT FACILITIES AT PLANT D


PROCESS WASTE
BAR SCREENS
NEUTRALIZATION BASIN
FINE SCREENS
PLANT SANITARY WASTE
SLUDGE RECYCLE
AERATION BASINS
(SERIES)
SECONDARY CLARIFIERS
SLUDGE HOLDING
(AERATED)
INFLUENT TO PILOT
PLANT TRAILER
CHLORINE CONTACT TANK
FINAL EFFLUENT

PLANT P

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant P, a Subcategory IV (Woven Fabric Finishing) and Subcategory VII (Stock and Yarn Dyeing) plant. The objectives of this pilot plant study were to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant P, determine the effectiveness of the technologies for meeting the BATEA guideline limitations, and define the mutually (ATMI, EPA, and ES) agreed upon recommendations for the most cost effective treatment process.

Existing wastewater treatment facilities at Plant P include screening, equalization, aeration, secondary clarification, chlorination, and sludge drying beds. The experimental testing was performed on the secondary clarifier effluent prior to chlorination.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations.

CONCLUSIONS

1. The existing wastewater treatment facilities at Plant P are effectively treating the textile plant wastewater and achieving the BPT guideline limitation values for all parameters.
2. To achieve the BATEA effluent limitations additional treatment beyond the BPT plant are required to remove TSS.
3. The following observations and conclusions were made from the pilot scale screening experiments at Plant P.
    a. Coagulation/Clarification and Multi-Media Filtration (Mode A) - The reactor/clarifier was operated with alum and then ferric chloride as coagulants at the optimum dosages determined by jar tests. The reactor/clarifier was ineffective for TSS, BOD_5, COD and TOC removal. TSS values increased across the clarifier because the solids coagulated but did not settle. The pollutant reduction that did occur took place in the multi-media filter. The multi-media filter removed some BOD_5, COD and TSS; however, these removals were not consistent.

b. Multi-Media Filter Followed by Carbon Columns (Mode B) - The multi-media filter reduced the effluent BOD_5, COD, TSS and color but did not provide a consistently low effluent TSS concentration. Apparently the secondary effluent contained a fine solids constituent that was difficult to remove by filtration. The carbon columns further reduced BOD_5, COD and color as well as removed chromium and phenol. The fine solids constituent was not removed by the carbon columns.

c. Multi-Media Filter Followed by Ozonation (Mode C) - The multi-media filter was operated with ferric chloride as a precoagulant in three of the six experiments. The filter's TSS removal performance was not consistent as discussed in Conclusion 2b. Ozone screening experiments were conducted in continuous operation at dosages of 16 to 69 mg/l ozone utilized. Ozone demonstrated the ability to reduce color but was not consistently effective for BOD_5, COD, TSS, TOC, chromium and phenol removal.

d. Ozonation (Mode D) - The ozonation experiments were conducted in both continuous and batch operation at dosages of 16 to 120 mg/l of ozone utilized. Ozonation appeared to be effective for color, COD and TOC removal at the high dosage rate.

e. Multi-Media Filter with Precoagulation (Mode F) - The multi-media filter was operated using ferric chloride, alum and a cationic polymer (American Cyanamid 515C) as precoagulants. The filter performance was not consistent and TSS removals varied from an increase in TSS to an 83 percent removal at the lowest loading rate of 3.1 gpm/ft^2. None of the precoagulants tested appeared to offer consistently good TSS removal.

f. Dissolved Air Flotation (Mode G) - The dissolved air flotation experiments were conducted by batch testing the BPT effluent.

Two tests were conducted using $FeCl_3$ at 10 mg/l (as Fe) as a coagulant. No float was developed in either test.

4. The three candidate BATEA process technologies (those showing the greatest potential for favorable treatment effectiveness) for Plant P are multi-media filter with precoagulation followed by carbon columns (Mode H), multi-media filter with precoagulation (Mode F), and multi-media filter (Mode I).

5. None of the candidate process technologies tested achieved a projected effluent quality that would meet the BATEA effluent limitations for TSS at Plant P. Mode H provided the best overall effluent quality although the difference in the projected 30-day average effluent TSS concentrations for Modes H and I is 16 mg/l versus 18 mg/l. The BATEA guideline limitation for TSS at Plant P is 15 mg/l.

RECOMMENDATIONS

1. Multi-media filtration is the recommended BATEA process for Plant P. The projected effluent TSS concentration does not meet the BATEA guideline value although all other BATEA guideline parameters will be achieved.

2. The recommended surface loading rate for the multi-media filter is 3 gpm/ft^2. Process design criteria are presented in Chapter VI.

3. Prior to installing multi-media filtration and/or other BATEA processes to achieve all parameter limitations, it is recommended that further testing of multi-media filtration be done in order to optimize the choice of media and the operating conditions. With this optimization the incremental removal may be sufficient to achieve the BATEA limits.

PLANT P

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the waste treatment plant effluent from the two manufacturing plants that comprise the Plant P manufacturing facility, a Subcategory IV (Woven Fabric Finishing) Plant and a Subcategory VII (Stock and Yarn Dyeing) Plant. The first plant is involved in a complex manufacturing operation of natural, synthetic and blends of natural and synthetic fibers. The second plant is involved in stock and yarn dyeing. The primary fibers used are cotton and polyester.

PRODUCTION DATA

The BATEA pilot plant was operated for a 76-day period (June 1, 1977 through August 15, 1977) at this site. The production during this same 76-day period totaled 9,245,225 pounds of material. The production during the days the plant was operating averaged 168,095 pounds/day (see letter in Appendix E). Materials included 100% cotton, 65% cotton/35% polyester, 85% cotton/15% polyester, 50% cotton/50% polyester, 75% polyester/25% cotton and 100% polyester. The two manufacturing plants have a capacity of approximately 200,000 pounds per day.

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant P is presented in Figure C-6(P). More specific process information is summarized in Table C-9(P). The treated wastewater included the industrial waste plus 7.5 percent (by volume) sanitary waste. The raw wastewater passes through a bar screen, then acid is added into the waste stream for neutralization prior to entering the equalization basin. Two parallel aeration basins with a total volume of 14 million gallons follows equalization. The detention time in the aeration basins is 78 hours. Aeration is provided by surface aerators at a power to volume ratio of 57 HP/MG. Following aeration, the bio-solids are separated from the water in two parallel final clarifiers. The sludge from the clarifiers is either returned to the aeration basins or pumped to sand drying beds. The supernatant from the secondary clarifiers is chlorinated and discharged.

TABLE C-9(P)

PLANT P

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow - 4.3 MGD

Equalization

No. of Basins - 1
Basin Size - 8 MG
Detention Time - 45 hrs
Unaerated

Neutralization

Acid feed prior to Equalization Basin

Nutrient Addition

None

Screening

Bar Screens - 1-3/8" O.C.

Aeration Basin

No. of Basins - 2 in Parallel
Volume (Total) - 14 MG
Aeration (Total) - 800 HP; 57 HP/MG
Detention Time - 78 hrs

Secondary Clarifiers

No. of Clarifiers - 2
Size: Diameter - 65 ft (inside diameter)
Side Water Depth - 10 ft
Recycle Rate - 2 MGD (total)

Other Facilities

Chlorination
Sand Drying Beds

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data, of the waste treatment plant as reported by the plant, are shown in Appendix A for the one-year period immediately prior to and including the period of the pilot study. Daily operating data, as reported by the plant, are also presented in Appendix A for the period the pilot studies were in progress. The discharge values reported for the last year are compared to the BPT guideline values in Table C-10(P). The effluent values reported in this table are final effluent numbers. The pilot plant trailer operated on the secondary clarifier effluent prior to chlorination.

Based on the data presented in Appendix A and in Table C-10(P), the waste treatment plant is within BPT guideline values for 30-day averages and daily maximums for all the parameters, with the exception of sulfide and phenol. The data on these two parameters were not available.

During the on-site experimental study there were no major effluent quality upsets created by production changes or biological treatment operations. Some unusual production occurrences that influenced the pilot plant operation are noted below:

- July 1 through July 10, 1977 - plant production facilities were shut down for a holiday.
- June 5, 12, 19 and 26, July 17, 24 and 31, August 6, 7, 14 and 15, plant production facilities were shut down for the weekend.

WATER USAGE

Based on an average wastewater flow of 2.0 MGD during the on-site study, 11.9 gallons of wastewater was generated per pound of finished material produced.

TABLE C-10(P)

PLANT P

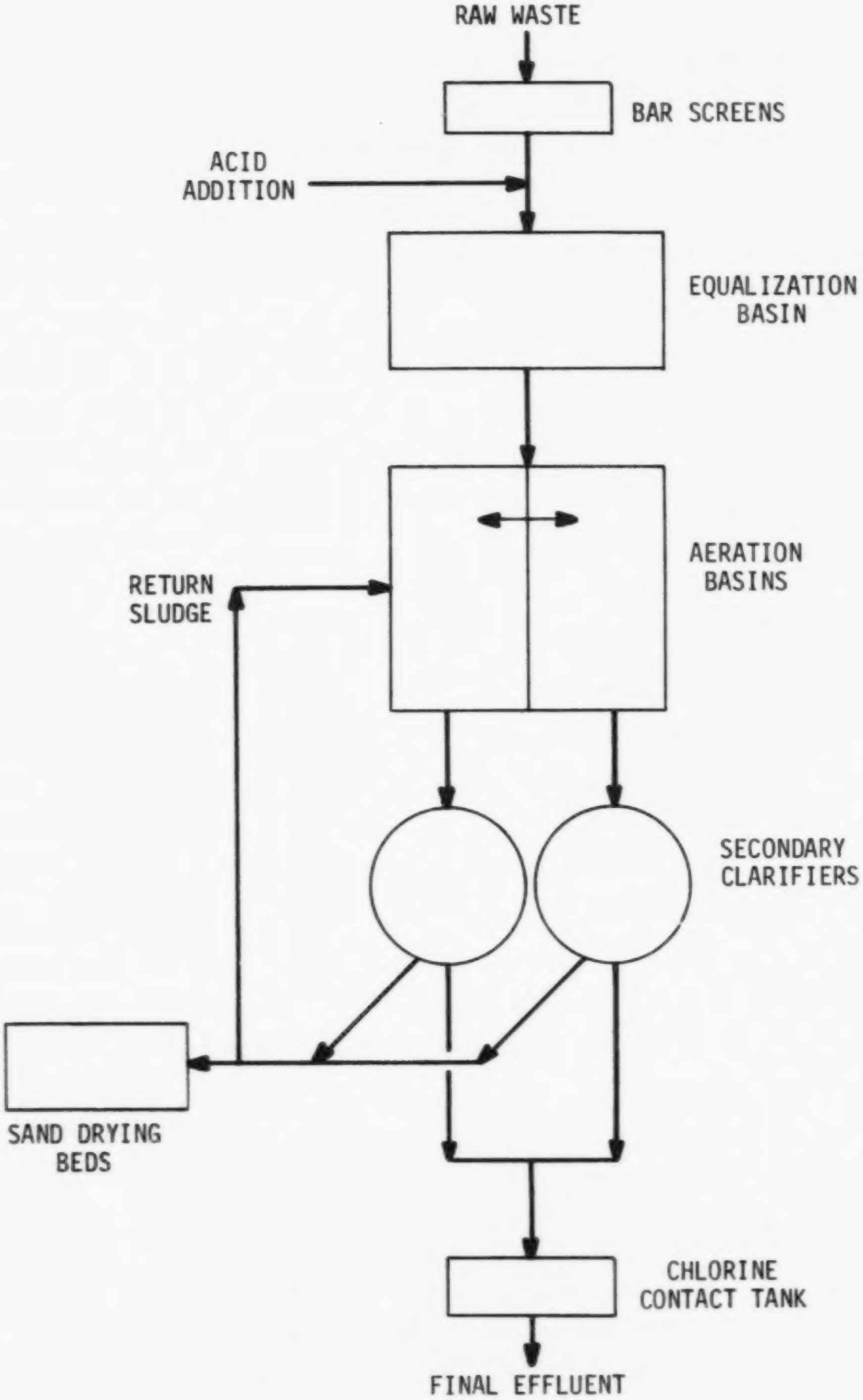
COMPARISON OF ACTUAL PERFORMANCE WITH BPT GUIDELINE VALUES

Parameter	BPT Guideline Values				Actual Operation July '76-Aug.'77	
	lbs/day[1]		mg/l at 2.0[2]		mg/l	
	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.	Avg.	Max.
BOD_5	556	1,111	33	67	7	17
COD	8,647	17,295	518	1037	181	630
TSS	1,495	2,989	90	179	8	20
Phenol	8.5	17.0	0.51	1.02	n.m.	n.m.
Chromium	8.5	17.0	0.51	1.02	<.03	<.04
Sulfide	17.0	34.0	1.02	2.04	n.m.	n.m.
Flow	n.a.	n.a.	n.a.	n.a.	2.0 MGD	3.4 MGD
pH	(6.0 - 9.0)		(6.0 - 9.0)		(8.3 - 8.8)	

(1) - See Appendix E for the calculations of the BPT Guideline Values.
(2) - Average Flow during the period July 1976 through August 1977 was 2.0 MGD.
n.m. - not measured.
n.a. - not applicable.

FIGURE C-6(P)

SCHEMATIC FLOW DIAGRAM-EXISTING WASTEWATER TREATMENT FACILITIES AT PLANT P


RAW WASTE
BAR SCREENS
ACID ADDITION
EQUALIZATION BASIN
AERATION BASINS
RETURN SLUDGE
SECONDARY CLARIFIERS
SAND DRYING BEDS
CHLORINE CONTACT TANK
FINAL EFFLUENT

PLANT V

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant V, a Subcategory IV (Woven Fabric Finishing) Plant. The objectives of this pilot plant study were to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant V, determining the effectiveness of the technologies for achieving the BATEA guideline limitations, and the mutually (ATMI, EPA and ES) agreed recommendations for the most cost-effective treatment process.

Existing wastewater treatment facilities at Plant V include screens, pH adjustment, two stage aeration, and secondary clarification. Sanitary waste may be chlorinated prior to being discharged into the waste treatment plant influent. The experimental testing was performed on the secondary clarifier effluent.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations.

CONCLUSIONS

1. The existing wastewater facilities at Plant V were not achieving the Best Practical Technology (BPT) guideline effluent limitations for COD or TSS during the period the pilot plant study was conducted.

2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations, additional treatment beyond BPT is required to reduce BOD_5, COD, and TSS.

3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant V.

    a. Coagulation/Clarification followed by Multi-Media Filtration (Mode A) - The reactor/clarifier did not operate effectly during the screening experiments because of the extreme variability of the TSS concentration in the secondary effluent. The reactor/clarifier did dampen out the TSS peaks before treatment by the multi-media filter. Alum at

40 mg/l as Al^{+3} was used as a coagulent. The filter removed BOD_5, COD, TOC, and TSS although the performance was effected by the influent TSS concentration.

b. Multi-Media Filtration Followed by Activated Carbon Adsorption (Mode B) - The variability of the TSS concentration of the secondary effluent severely effected the performance of the multi-media filter. When the filter could be operated it removed BOD_5, COD, TSS, and color. Filter run times varied from less than 15 minutes to 12 hours. The activated carbon columns further reduced BOD_5, COD, TSS, TOC, and color.

c. Multi-Media Filtration Followed by Ozonation (Mode C) - The multi-media filter was effective in removing BOD_5, COD, TSS, and TOC during this screening experiment. Ozone reduced COD and color but TOC and BOD_5 increased during ozonation.

d. Ozonation (Mode D) - As in Mode C experiment ozone demonstrated the ability to reduce COD and color but was ineffective in reducing BOD_5 and TOC.

e. Multi-Media Filtration with Precoagulation (Mode F) - The multi-media filter operated with alum at 1 mg/l (Al^{+3}) as a precoagulant was not an effective process. The filter provided reduction of BOD_5, COD, TOC, AND TSS, however, filter run times were short because of the high TSS concentration.

f. Dissolved Air Flotation (Mode G) - The bench-scale dissolved air flotation (DAF) experiment demonstrated moderate reduction of BOD_5, COD, AND TSS using 40 mg/l alum (Al^{+3}) as a coagulant.

4. The candidate BATEA process technologies (those showing the greatest potential for favorable treatment effectiveness) for Plant V are the combination of reactor/clarifier followed by multi-media filter followed by carbon columns (Mode H).

5. The candidate BATEA process evaluated (reactor/clarifier followed by multi-media filter followed by carbon columns) did not produce a projected effluent quality that could achieve the

BATEA guideline values for COD and TSS. The BATEA guideline values for COD and TSS are 161 mg/l and 12 mg/l, respectively, and the projected values from the pilot plant operation of Mode H for COD and TSS are 204 mg/l and 24 mg/l, respectively. Because of the variable effluent quality from the secondary treatment plant the pilot plant could not be operated for the desired period sufficient for collecting data to provide an adequate process design. A decision was made by ATMI/EPA/ES to abandon pilot plant operation at Plant V prior to collecting the required number of data points due to effluent quality upsets experienced at this plant.

RECOMMENDATIONS

1. An engineering and operational evaluation of the existing wastewater treatment system at Plant V is recommended before proceeding with the development of BATEA technology for end-of-pipe treatment. The present effluent did not meet the BPT guideline limitations for COD and TSS during the pilot plant study and severely hampered operation of the BATEA pilot plant experimental equipment. Improvements in BPT effluent quality are necessary to make BAT treatment technically possible.
2. If the secondary effluent quality remains as defined in Table V-9 for Mode H operation, then coagulation clarification followed by multi-media filtration followed by carbon adsorption is the recommended BATEA process for Plant V. The projected effluent quality for this process will not achieve the BATEA guideline values for COD and TSS.
3. The recommended overflow rate for the reactor/clarifier is 400 gpd/ft^2 and the recommended chemicals are alum for coagulant at 40 mg/l as Al^{+3} and acid. The recommended surface loading for the multi-media filter is 3 gpm/ft^2. The recommended empty bed hydraulic retention time for the carbon columns is 45 minutes. Process design criteria are presented in Chapter VI.

PLANT V

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the wastewater treatment plant (WTP) effluent of the Plant V textile manufacturing facility, a Subcategory IV (Woven Fabric Finishing) Plant. This plant is involved in simple and complex manufacturing operations of blends of natural and synthetic fibers. The primary fibers used are cotton and polyester. The production processing includes desizing (PVA/CMC/starch), scouring, bleaching, mercerizing, dyeing (continuous) and special finishes (mildew, soil and water repellent and hand improvers).

PRODUCTION DATA

The BATEA pilot plant was operated for a 61-day period (November 28, 1977 through January 27, 1978) at this site. The production during this same 61-day period totaled 9,012,499 pounds of material. The production during the days the plant was operating averaged 209,593 pounds/day (see letter in Appendix E). Materials produced included the following blends; 65% polyester/35% cotton (55.9% of total), 50% polyester/50% cotton (26.3% of total), 20% polyester/80% cotton (7% of total), 18% polyester/82% cotton (9% of total) and 15% polyester/85% cotton (1.8% of total). The manufacturing plant has a capacity of approximately 236,000 pounds per day.

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant V is presented in Figure C-7(V). More specific process information is summarized in Table C-11(V). Approximately 15,000 gallons per day of sanitary wastewater generated at the plant is chlorinated and then combined with the industrial wastewater prior to treatment. The raw wastewater passes through a bar screen, then acid is added into the waste stream for neutralization prior to biological treatment. Following neutralization the wastewater is biologically treated in an extended aeration activated sludge system consisting of two aeration basins operated in series with a

TABLE C-11(V)

PLANT V

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow

4 MGD

Equalization

None

Neutralization

Acid feed prior to aeration basin

Nutrient Addition

None

Screening

Bar Screens (1 5/8" spacing)

Aeration Basin

No. of Basins - 2 in series
Volume (total) - 10 MG
Aeration (total) - 410 HP; 41 HP/MG
Detention Time - 60 hrs.
Aerator Type - surface

Secondary Clarifiers

No. of Clarifiers - 1
Size: Diameter - 125 ft.
Side Water Depth - 8 ft.
Recycle Rate - 2.3 MGD

total volume under aeration of 10 million gallons at a design detention time of 60 hours. Aeration is provided by surface aerators at a power to volume ratio of 41 HP/MG. Typical mixed liquor suspended solids (MLSS) levels of approximately 1500 mg/l are maintained in the aeration basins. The sludge age in the aeration basin is approximately 100 days. Following aeration, the suspended solids are separated from the water by gravity sedimentation in a 125-foot diameter final clarifier. The sludge from the clarifier is returned to the aeration basins. There is no intentional sludge wasting at Plant V. The supernatant from the clarifier is discharged to the receiving stream.

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data for the wastewater treatment plant as reported by the plant for the one-year period immediately prior to and including the period of the pilot study are presented in Appendix A. Daily operating data, as reported by the plant for the period the pilot studies were in progress, are also presented in Appendix A. The discharge values reported for the last year are compared with the BPT guideline values in Table C-12(V). The WTP reported values in excess of the BPT guideline values for both 30-day averages and daily maximums during several months in the previous year. The major exceptions were for TSS and COD.

During the on-site experimental study the effluent quality exhibited extreme variability. The effluent quality upsets experienced at the WTP appear to be design and/or operation related or production related and do not appear to be solely related to cold weather (as can be seen in Table I, Appendix A, the performance was poor at times even in summer months).

The plant production facilities were shutdown each weekend, and the influent flow to the WTP was essentially zero on weekends. The production facility also shutdown on December 26 and 27 for Christmas.

WATER USAGE

Based on an average wastewater flow of 3.06 MGD during the on-site study, 14.6 gallons of wastewater were generated per pound of finished material produced.

TABLE C-12(V)

PLANT V

COMPARISON OF ACTUAL PERFORMANCE WITH BPT GUIDELINE VALUES

	BPT Guideline Values(1)				Actual Operation Feb. '77 - Jan. '78 mg/1	
	lbs/day		mg/1 at 3.13 MGD(2)		Range(3)	
Parameter	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.(4)
BOD_5	692	1,383	27	53	11.7-40.0{2}	132{4}
COD	12,576	25,151	482	963	318-628{2}	1576{5}
TSS	1,865	3,731	71	143	23.3-240{6}	953{8}
Phenol	10.5	21.0	0.4	0.8	.0018-.021	.021
Chromium	10.5	21.0	0.4	0.8	<.005-<.099	.11
Sulfide	21.0	41.9	0.8	1.6	.246-16.9{2}	28.8{2}
Flow	n.a.	n.a.	n.a.	n.a.	3.13	5.43
pH	................Within Range 6.0-9.0.....................				Within Range 8.0 - 10.3	

---

(1) See Appendix E for the calculations of BPT Guideline Values.
(2) The average flow for the period February 1977 through January 1978 was reported by the plant as 3.13 MGD.
n.a. not applicable
(3) Range of 30-Day Avg. X - X {number of occurrances above BPT guideline values}.
(4) Daily Maximum {number of months with values above BPT guideline limitations}.

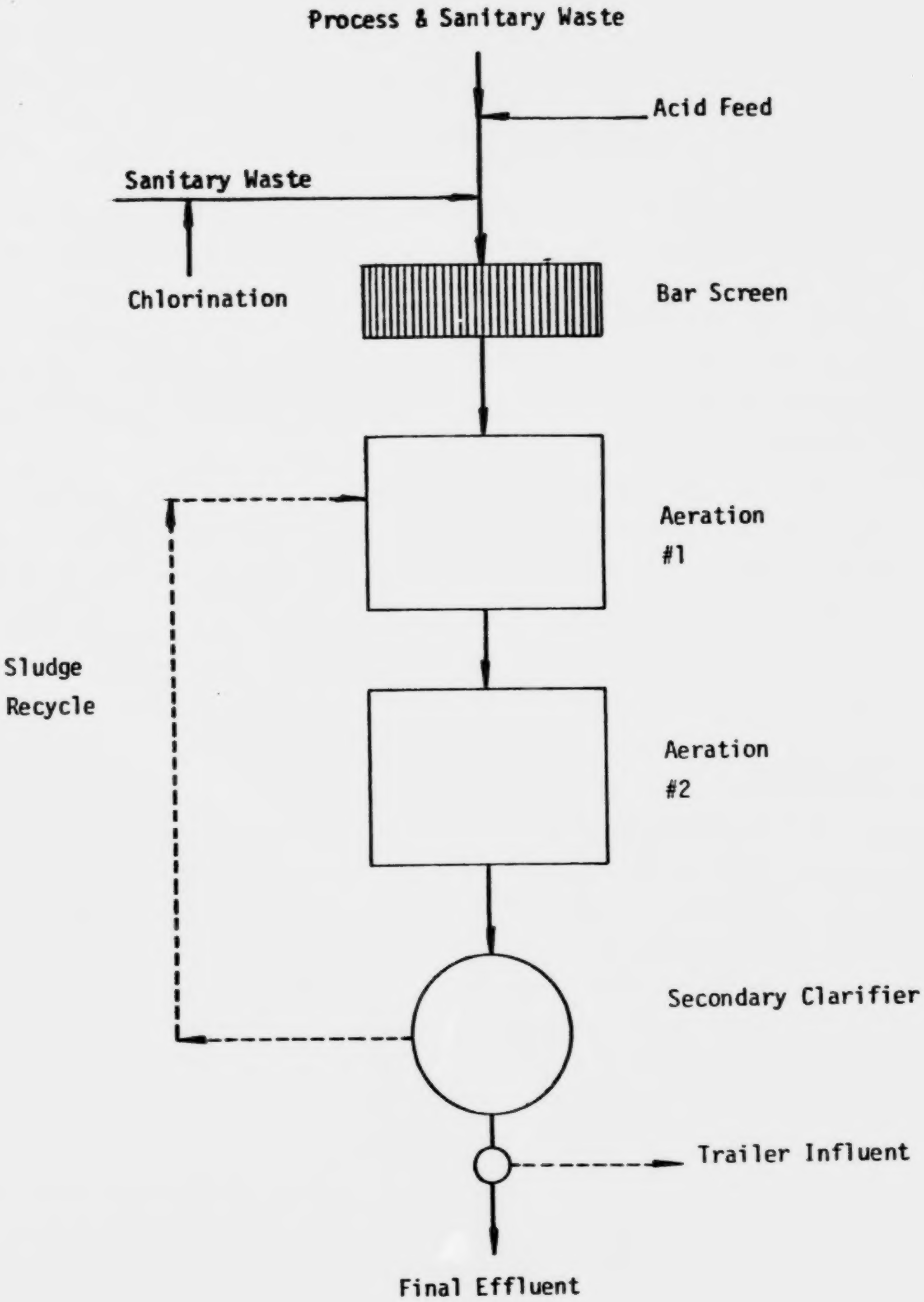

Process & Sanitary Waste
Acid Feed
Sanitary Waste
Chlorination
Bar Screen
Aeration #1
Sludge Recycle
Aeration #2
Secondary Clarifier
Trailer Influent
Final Effluent

FIGURE C-7(V)

SCHEMATIC FLOW DIAGRAM - EXISTING WASTEWATER TREATMENT FACILITY - PLANT V

PLANT Y

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant Y, a Subcategory IV, Woven Fabric Finishing plant. The objectives of this pilot plant study are to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant Y, determine the effectiveness of the technologies for achieving the BATEA guideline limitations and define the mutually (ATMI, EPA and ES) agreed upon recommendations for the most cost-effective treatment process(es).

Existing wastewater treatment facilities at Plant Y include screens, equalization, acid addition, aeration, polymer addition, secondary clarification and sludge drying beds. The experimental testing was performed on the secondary clarifier effluent.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations.

CONCLUSIONS

1. The existing wastewater facilities at Plant Y, as presently operated, were not consistently meeting the Best Practical Technology (BPT) guideline effluent limitations as a monthly average for TSS during the period the pilot plant study was conducted. Historically (1 year period prior to pilot plant visit) there were excursions above the BPT limits for BOD_5, Sulfide and TSS for both the 30-day average and daily maximum values. Daily maximum values for pH exceeded the BPT effluent limitations in 5 out of 12 months.
2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations additional treatment beyond BPT is required to reduce BOD_5, TSS and COD based on data collected during the pilot plant visit.
3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant Y.

a. Coagulation/Clarification followed by Multi-Media Filtration (Mode A) - The reactor/clarifier effectively reduced BOD_5, COD and color from the BPT effluent. However, TSS concentrations were not consistently reduced. The optimum coagulant combination was alum at 45 mg/l as Al^{+3} at a pH of 7.0. The most effective performance was achieved at an overflow rate of 340 gpd/ft^2. The multi-media filter provided the best additional removal of BOD_5, COD and TSS at the loading rate of 3 gpm/ft^2.

b. Multi-Media Filtration Followed by Activated Carbon Adsorption (Mode B) - The multi-media filter reduced the TSS level by 45 percent at the most effective loading rate of 5.0 gpm/ft^2. BOD and COD were also reduced through the filter. The carbon column reduced the BOD, COD, TSS and Chromium further. Total Mode B reductions include 50 percent BOD_5, 75 percent COD, 52 percent TSS and 28 percent Chromium at the most effective filter loading rate.

c. Multi-Media Filtration Followed by Ozonation (Mode C) - The Mode C batch tests were conducted with effluent from the multi-media filter while being operated at a surface loading rate of 7.0 gpm/ft^2. This high rate was practical because the BPT effluent TSS level was less than 1 mg/l during the test. Ozone dosages from 0.25 to 12.0 lb O_3 utilized per lb COD with the utilization ranging from 15.5 to 765 mg/l O_3, removed a small amount of color and COD, but TOC and BOD_5 increased during ozonation. At 765 mg/l O_3 utilized, 32 percent reduction of COD was achieved.

d. Ozonation (Mode D) - Ozonation of the BPT effluent was generally ineffective for removal of BOD_5, TOC and Chromium. The effect of TSS was irrelevant during the batch test since BPT effluent TSS values were less than 1 mg/l at the time Mode D was operated. Ozone utilized dosages of 0 to 312 mg/l were evaluated with 42 percent COD removal achieved at 312 mg/l O_3 utilized dosage. Normal BPT effluent TSS values were to high for this process technology to be considered a candidate mode.

e. Multi-Media Filtration with Precoagulation (Mode F) - The multi-media filter operated with 1 mg/l alum as Al^{+3}, as a pre-filter aid. The filter provided some reduction of BOD_5, COD and TSS, but no consistant major improvement in performance over multi-media filtration without precoagulation was evident.

f. Dissolved Air Flotation (Mode G) - A bench-scale dissolved air flotation (DAF) experiment at 100% recycle using 45 mg/l Al^{+3} as a coagulant was not effective for either TSS, COD nor chromium reduction. An increase in these parameters was noticed due to addition of alum as a coagulant. A reasonable float could not be achieved.

4. The candidate BATEA process technology showing the greatest potential for favorable treatment effectiveness for Plant Y is multi-media filter followed by carbon columns (Mode B).

5. Mode B achieved all the BATEA effluent guideline values at Plant Y.

RECOMMENDATIONS

1. Multi-media filtration followed by granular carbon adsorption is the recommended BATEA process for Plant Y. The projected effluent quality for this process will achieve all BATEA guideline values.

2. The recommended multi-media filter surface loading is 5 gpm/ft^2. The carbon column hydraulic residence time should be 45 minutes. The carbon capacity loading is 0.104 lb Soluble COD/lb carbon. Process design criteria are presented in Chapter VI.

PLANT Y

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the waste treatment plant effluent from the Plant Y textile manufacturing facility. Plant Y is a Subcategory IV (Woven Fabric Finishing) mill which includes a yarn dyeing operation. The woven fabric finishing which comprises 92.9% of the total production is a complex manufacturing operation using natural, synthetic and blends of natural and synthetic fibers. The yarn dye operation accounts for the remaining 7.1 percent of the plant production. The primary fibers used are synthetic polyesters and blends of polyester with cotton, rayon and wool. The production processing includes desizing, scouring, dyeing, bleaching and mercerizing. The sizings used at Plant Y are starch, PVA, CMC, acrylic binders and wax. Special finishes include resin, fluoro-carbon and silicone.

PRODUCTION DATA

The BATEA pilot plant was operated at the Plant Y site for a 42-day period (October 12, 1977 through November 22, 1977). During this time, the woven fabric finishing plant operated for 35 days, averaging a production of 67,693 pounds of material per day while the yarn dye production averaged 5153 pounds per day (see Appendix E). Finishing production for the duration of the pilot plant visit totaled 2,549,583 pounds of material, including 100% polyester, 65% polyester/35% cotton, 50% polyester/50% cotton, 75% polyester/25% wool, 100% wool, 100% nylon, 100% acrylic; 70% polyester/30% acrylic; 50% polyester/50% rayon, 50% rayon/50% acetate and 90% polyester/10% nylon. The manufacturing plant has a predicted capacity of 127,000 lbs/day Woven Fabric and 20,000 lbs/day yarn dyeing.

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant Y is presented in Figure C-8(Y). More specific process information is summarized in Table C-13(Y).

TABLE C-13(Y)

PLANT Y

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow = 3.5 MGD (0.5% sanitary waste)

Flow during Pilot Plant Visit - 2.12 MGD

Influent BOD_5 - 350 mg/l

Equalization

Aerated: Volume - 4.6 MG
Aeration - 120 HP, 26.1 HP/MG

Neutralization

Acid Addition

Nutrient Addition

None

Screening

Bar Screens - 3/4 inch

Aeration Basin

No. of Basins - 2

Basin Volume - 10.5 MG (total)

Aeration - 600 HP (surface aerators), 57.1 HP/MG

Detention Time - 72 hours at Design Flow
119 hours at Flow experienced during pilot plant visit.

Secondary Clarifiers

No. of Clarifiers - 2

Size: Diameter - 60 ft.
Side Water Depth - 8 ft.
Recycle rate - 1.8 MGD

Other Operations

Polymer Addition following aeration basins

Sludge Drying Beds

The incoming waste is primarily industrial with approximately 0.5% being sanitary waste. Raw waste enters an aerated equalization basin. Acid addition is utilized for pH adjustment prior to a 3/4-inch bar screen which removes the larger objects. After screening, two aeration basins are operated in parallel with a total volume of 10.5 million gallons at a design detention time of 72 hours. Aeration is provided by surface aerators at a power to volume ratio of 57.1 HP/MG. After the two streams leave the aeration basins, polymer is added to faciliatate solids settling before entering the secondary clarifiers. Sludge is returned to the aeration basins or can be transferred to sludge drying beds for dewatering. Sludge return capability at the plant is approximately 0-150% (three 1.8 MGD pumps).

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data of the waste treatment plant as reported by the plant are shown in Appendix A for the one-year period immediately prior to and including the period of the pilot study. The discharge values reported for the last year are compared to the Best Practical Treatment (BPT) guideline values in Table C-14(Y). The influent to the pilot plant trailer was collected from the secondary clarifier effluent.

Based on the data presented in Table C-14(Y) and the influent BOD_5 value from Table C-13(Y), the waste treatment plant is obtaining an overall average BOD_5 removal efficiency of 96 percent. Excersions above the BPT limitations for BOD_5, TSS and sulfides were experienced for both 30-day average and maximum day values during the 12-month period. The pH limitation was exceeded 5 times based on maximum day values.

For the major portion of the on-site visit there were very few operational/control problems with the Plant Y treatment facility. The most significant problem occurred when the clarifier arms malfunctioned causing high solids concentrations in the BPT effluent. This hindered effective operation of the mobile pilot plant.

TREATMENT PLANT INFLUENT VARIABILITY

During the period of pilot plant study, the textile manufacturing plant generally operated six days per week. This variability is not

TABLE C-14(Y)

PLANT Y

COMPARISON OF ACTUAL PERFORMANCE WITH BPT GUIDELINE VALUES

PARAMETER	BPT Guideline Values				Actual Operation(3)	
	lbs/day1)		mg/1 at 2.03 MGD2)		Dec. '76 - Nov. '77 mg/1	
	30-DAY AVG.	DAILY MAX.	30-DAY AVG.	DAILY MAX.	30-DAY AVG.	DAILY MAX.
BOD_5	242	482	14	29	2.3-24(2)	2.5-42 (1)
COD	4042	8084	239	477	99-207(0)	109-308 (0)
TSS	648	1295	38	76	29-58(7)	36-207 (2)
Phenol	3.7	7.4	0.22	0.44	.01-.09(0)	.010-.090 (0)
Chromium	3.7	7.4	0.22	0.44	.01-.03(0)	.011-.030 (0)
Sulfide	7.4	14.8	0.44	0.88	<0.1-<10(3)	0.1-<10 (3)
Flow, (MGD)	n.a.	n.a.	n.a.	n.a.	1.75-2.34	2.48-3.03
pH, (unitless)	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	7.8-8.1 (0)	8.4-10.0 (5)

---

(1) See Appendix E for the calculations of the BPT Guideline Values.

(2) Average flow for the period of December '76 through November '77 as reported by the plant.

(3) The figures in parentheses represent the number of months in the 12-month period in which the plant monthly averages or maximum values exceed the BPT guidelines.

n.a. - not applicable.

reflected in the overall statistical treatment of the data in this report, as only days when data was available were included. During periods of low flow the aeration basin has enough retention time to maintain a suitable biological population. The mean cell retention time cannot be estimated based on insufficient plant data.

WATER USAGE

Based on an average wastewater flow of 2.12 MGD during the on-site study, 29.1 gallons of wastewater were generated per pound of finished material produced. This is considerably higher than the industry average. This figure includes both the woven fabric finishing and the yarn dye production.

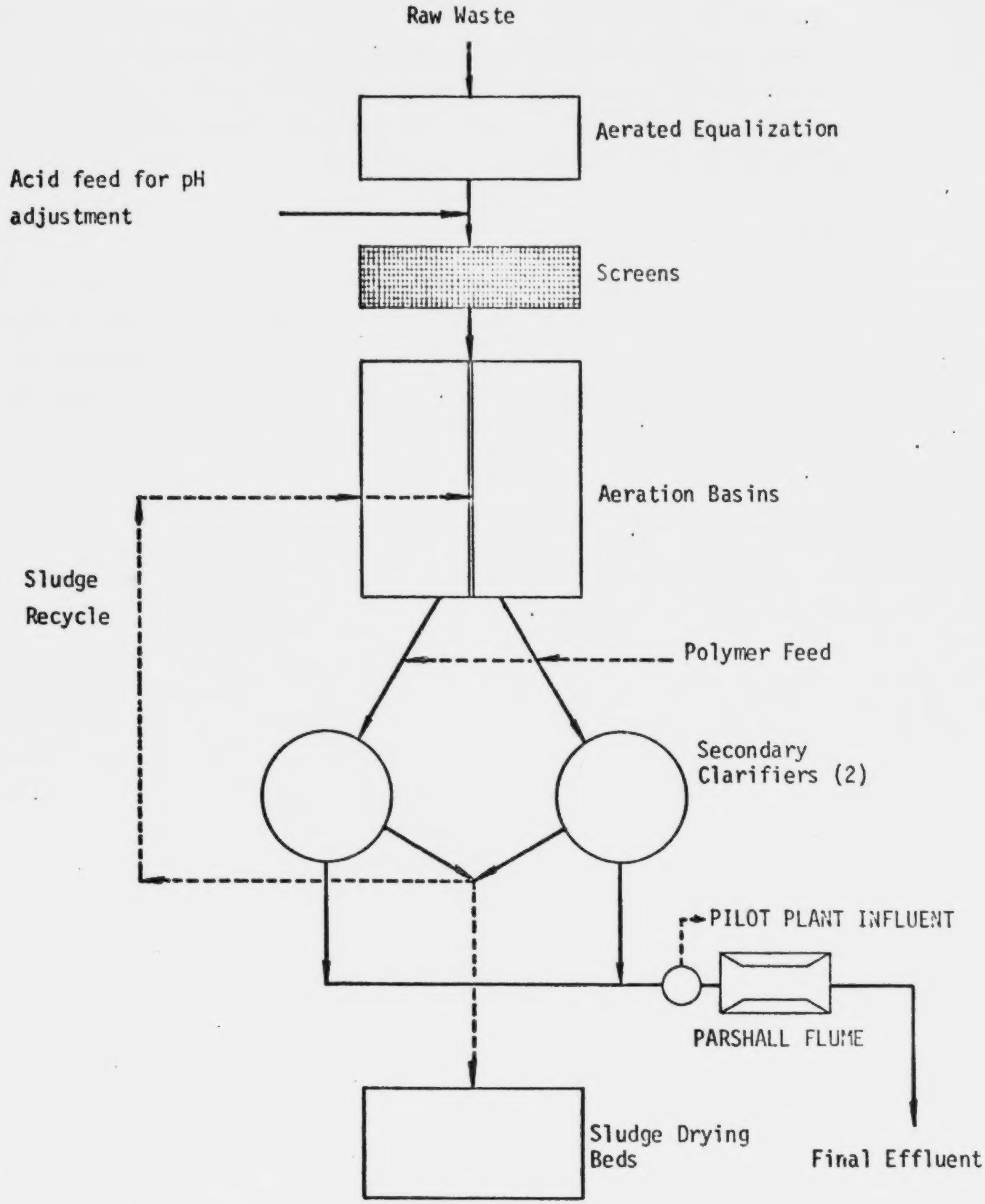

Raw Waste
Aerated Equalization
Acid feed for pH adjustment
Screens
Aeration Basins
Sludge Recycle
Polymer Feed
Secondary Clarifiers (2)
PILOT PLANT INFLUENT
PARSHALL FLUME
Sludge Drying Beds
Final Effluent

FIGURE C-8(Y)
SCHEMATIC DIAGRAM - EXISTING WASTEWATER
TREATMENT FACILITIES AT PLANT Y

PLANT Z

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant Z, a Subcategory IV, Woven Fabric Finishing plant. The objectives of this pilot plant study are to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant Z, determine the effectiveness of the technologies for achieving the BATEA guideline limitations and define the mutually (ATMI, EPA and ES) agreed upon recommendations for the most cost-effective treatment process(es).

Existing wastewater treatment facilities at Plant Z include screens, comminutors, aeration, secondary clarification, sludge digestion, sludge thickening and sludge landspreading. The experimental testing was performed on the secondary clarifier effluent.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations.

CONCLUSIONS

1. The existing wastewater facilities at Plant Z were achieving the Best Practical Technology (BPT) 30-day average guideline effluent limitations during the period the pilot plant study was conducted.
2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations additional treatment beyond BPT is required to reduce TSS, BOD and COD.
3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant Z.
    a. Coagulation/Clarification followed by Multi-Media Filtration (Mode A) - A variety of metallic coagulants and combinations of coagulants as well as cationic polymers were jar tested for effectiveness of transmittance improvement, turbidity reduction and minimal sludge production. However, none were found effective at reasonable coagulant dosages. In fact, the optimum coagulant and dosage in terms of transmittance improvement was alum at a dosage of 200 mg/l as Al^{+3} with caustic

adjustment to pH 8.0. Several reactor/clarifier experiments were conducted at overflow rates of 400, 600 and 800 gpd/ft^2. Although good removal of BOD and COD and transmittance improvement was obtained the TSS level generally increased across the clarifier. This was caused primarily by difficulty in maintaining steady state at pH 8.0 and a floating solids problem which could also be duplicated and verified by jar tests. Due to high coagulant dosage requirements and operational problems associated with the use of alum this mode of operation is not practical at Plant Z.

b. Multi-Media Filtration Followed by Activated Carbon Adsorption (Mode B) - The multi-media filter reduced the TSS level by 63% and COD by 15% at the optimum loading rate of 3 gpm/ft^2. Carbon columns operating following the filters removed an additional 40-45% soluble COD, 50% BOD$_5$, 38% TSS and 43% color using Westvaco WV-L granular carbon and a hydraulic resistence time of 45 minutes.

c. Multi-Media Filtration Followed by Ozonation (Mode C) - The Mode C batch tests were conducted with effluent from the multi-media filter at a surface loading rate of 3 gpm/ft^2. Effluent TSS ranged from 13 to 29 mg/l and COD from 538 to 652 mg/l. Ozone dosages of 0 to 2551 mg/l ozone utilized or 0 to 3.91 pounds of ozone utilized per pound of COD applied were evaluated. Excellent color removal (30%) was achieved at 25 to 75 mg/l ozone utilized dosage. Measurable COD and TOC reductions were not achieved until 411 mg/l 0_3 was utilized.

d. Ozonation (Mode D) - Ozonation of the BPT effluent was generally ineffective for removal of BOD$_5$, COD and TOC. BPT effluent TSS levels ranged from 25 to 57 mg/l while COD ranged from 407 to 482 mg/l. Ozone utilized dosages of 0 to 4544 mg/l 0_3 utilized were evaluated which corresponds to 0 to 11.2 pound 0_3 utilized per pound COD applied. Mode D results were similar to Mode C test results since high dosages of ozone were required to achieve measurable COD or TOC reduction. In fact, only 18% reduction of COD was obtained at 335 mg/l ozone dosage.

e. Multi-Media Filtration with Pre-coagulation (Mode F) - Effective COD, TSS and BOD reduction was obtained with the multi-media filter operated at 3 and 5 gpm/ft^2 surface loading rates with 10 mg/l alum as Al^{+3} as a coagulant aid. At the optimum filter loading rate of 3 gpm/ft^2 (in terms of effluent quality and filter run times) 41% BOD, 48% COD and 71% TSS was removed. Filter performance was similar to non-coagulated operation in terms of reduction of all parameters except COD. Pre-filter coagulation increased COD removal by 33%.

f. Dissolved Air Flotation (Mode G) - Bench-scale dissolved air flotation (DAF) experiments were performed at 100%, 50% and 33% recycle using 35 mg/l Alum as Al^{+3} as a coagulant. Only 8% COD removal was obtained at 50% recycle while the subnatant TSS was higher than the BPT effluent.

4. The candidate BATEA process technologies showing the greatest potential for favorable treatment effectiveness for Plant Z were multi-media filter followed by carbon columns (Mode B) and multi-media filtration with pre-coagulation followed by ozonation (Mode K).

5. Mode B achieved all the BATEA guideline values for Plant Z except COD which was above the limitation value by 100 mg/l. Mode K effluent exceeded the BATEA limits for COD and TSS.

RECOMMENDATIONS

1. Multi-media filtration followed by granular carbon adsorption is the recommended BATEA process for Plant Z. The projected effluent quality for this process will achieve all BATEA guideline values except COD.

2. The recommended multi-media filter surface loading rate is 3 gpm/ft^2. The carbon column hydraulic residence time should be 49 minutes. The carbon capacity loading is 0.12 gm soluble COD/gm carbon. Process design criteria are presented in Chapter VI.

PLANT Z

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the waste treatment plant effluent that comprises the Plant Z manufacturing facility, a Subcategory IV (Woven Fabric Finishing) Plant. Processes include printing (natural), desizing, scouring, bleaching, mercerizing, dyeing (Roller/Screen) and special finishes. Primary fibers used include cotton and blends of cotton/polyester.

PRODUCTION DATA

The BATEA pilot plant was on-site for a 57-day period (December 22, 1977 to February 16, 1978) at this site. The production during the 35-days of plant operation totaled 13,630,015 pounds of material. The production during the days the plant operated averaged 389,425 pounds/day (See Appendix F). Production averaged 9% cotton and 91% cotton/polyester blends. According to the textile mill, the manufacturing plant has a capacity of 457,000 pounds per day.

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant Z is presented in Figure C-9(Z). More specific process information is summarized in Table C-15(Z).

The incoming raw waste passes through a bar screen before the waste enters the first aeration basin. The two aeration basins have a volume of 20 million gallons each with a combined detention time of 107 hours at design flow. Currently one aeration basin is not in use. Aeration is provided by surface aerators at a power to volume ratio of 45 HP/MG. Following aeration, the bio-solids are separated from the water in two final clairifiers. Sludge is either returned to the aeration basin or pumped to the aerobic digester. Following the digester, sludge is concentrated in a thickener. Waste sludge is then landspreaded using a spray irrigation method. The normal sludge age

TABLE C-15(Z)

PLANT Z

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Flow - 9.0 MGD Design
3.40 MGD During Pilot Plant Visit
3.71 Average for previous 12-month period

Equalization

None

Neutralization

None

Nutrient Addition

None

Screening

Bar Screens - 2-in (parallel, vertical)
Comminutor - (1) on domestic waste stream

Aeration Basin

No. of Basins	2
Volume (Total)	40 MG
Aeration	1800 HP; 45 HP/MG
Detention Time	107 HR (at Design Flow) 141 HR (during pilot plant visit) 129 HR (12-month Average flow)

Secondary Clarifiers

No. of Clarifiers - 2
Size: Diameter - 85 ft.
Side Water Depth - 9 ft
Recycle rate - 1.15 MGD (total)

Chlorination Facilities

None

Sludge Digestion

No. of Tanks - 1

Sludge Concentrator

No. of Basins - 1
Sludge Holding - 1.3 MMG

ranges from 48 to 376 days. The supernatant from the secondary clarifier passes through a parshall flume and is discharged to the receiving stream.

EXISTING WASTEWATER TREATMENT PERFORMANCE

The monthly operating data of the waste treatment plant, as reported by the plant, are shown in Appendix A for the one-year period immediately preceding the period of pilot study. Daily operating data as reported by the plant are also presented in Appendix A for the period the pilot studies were in progress. The discharge values for the last year are compared to the present BPT values in **Table C-16(Z)**.

Based on the data presented in Appendix A and in Table C-16(Z) the waste treatment plant obtained an overall BOD_5 removal efficiency of 96 percent and achieved all BPT guideline values except for a few daily maximum excursions on TSS and a monthly average violation for BOD_5 during 1977.

During the on-site experimental study there were several major effluent quality upsets created by either production changes or biological treatment operational problems. Some of the unusual production and waste treatment plant operational occurrences which influenced the pilot plant operation are summarized below:

DATE	DESCRIPTION OF PROBLEM	EFFECT ON PILOT PLANT OPERATION
January 12, 13, 1978 January 17, 1978	Secondary clarifier sludge blanket carryover resulted in abnormally high TSS concentration to the pilot plant. Plant Z treatment plant was unable to waste sufficient biosludge to the landspread area due to the frozen turf and potential runoff to a receiving stream.	Decreased multimedia filter run time from normal 12 hours or more to less than 2 hours.
January 20, 23, 24, 1978	High TSS carryover the secondary clarifier weirs was most probably due to insufficient sludge wasting. Grab samples of BPT waste indicated a high CO_2 or N_2 level as solids tended to float in beakers.	(1) Floating solids in reactor clarifier. (2) High solids and short filter run times in multi-media filter operation. (3) High TSS loading to carbon columns.

TABLE C-16(Z)

PLANT Z

COMPARISON OF ACTUAL PERFORMANCE TO BPT LIMITATIONS

	Present BPT Values				Actual Operation*	
					Jan. 1977 - Dec. 1977	
	lbs/day		mg/1 at 3.71 MGD		mg/1	
Parameter	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.	30-Day Avg.	Max. Day
BOD_5	1285	2570	42	83	16 - 57 (1)	21 - 73
COD	22,665	45,330	733	1465	291 -594	394 -763
TSS	3466	6932	112	224	13 - 63	25 -229 (1)
Phenol	19.5	38.9	0.63	1.26	n.m.	n.m.
Chromium	19.5	38.9	0.63	1.26	n.m.	n.m.
Sulfide	39.0	77.9	1.26	2.52	n.m.	n.m.
Color	n.a.	n.a.	n.a.	n.a.	n.m.	n.m.
Flow	n.a.	n.a.	n.a.	n.a.	2.74-4.64	4.54-8.51
pH	6-9	6-9	6-9	6-9	8.0 -8.8	8.2 -9.4 (2)

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*Number in parenthesis indicates number of times BPT limits were exceeded.

Variations in BPT effluent quality, particularly TSS ($\bar{x}$ = 99 mg/l, σ = 178 mg/l) during the three week screening period posed extreme operational constraints on the pilot plant and subsequently affected selection of candidate processes and associated operating conditions.

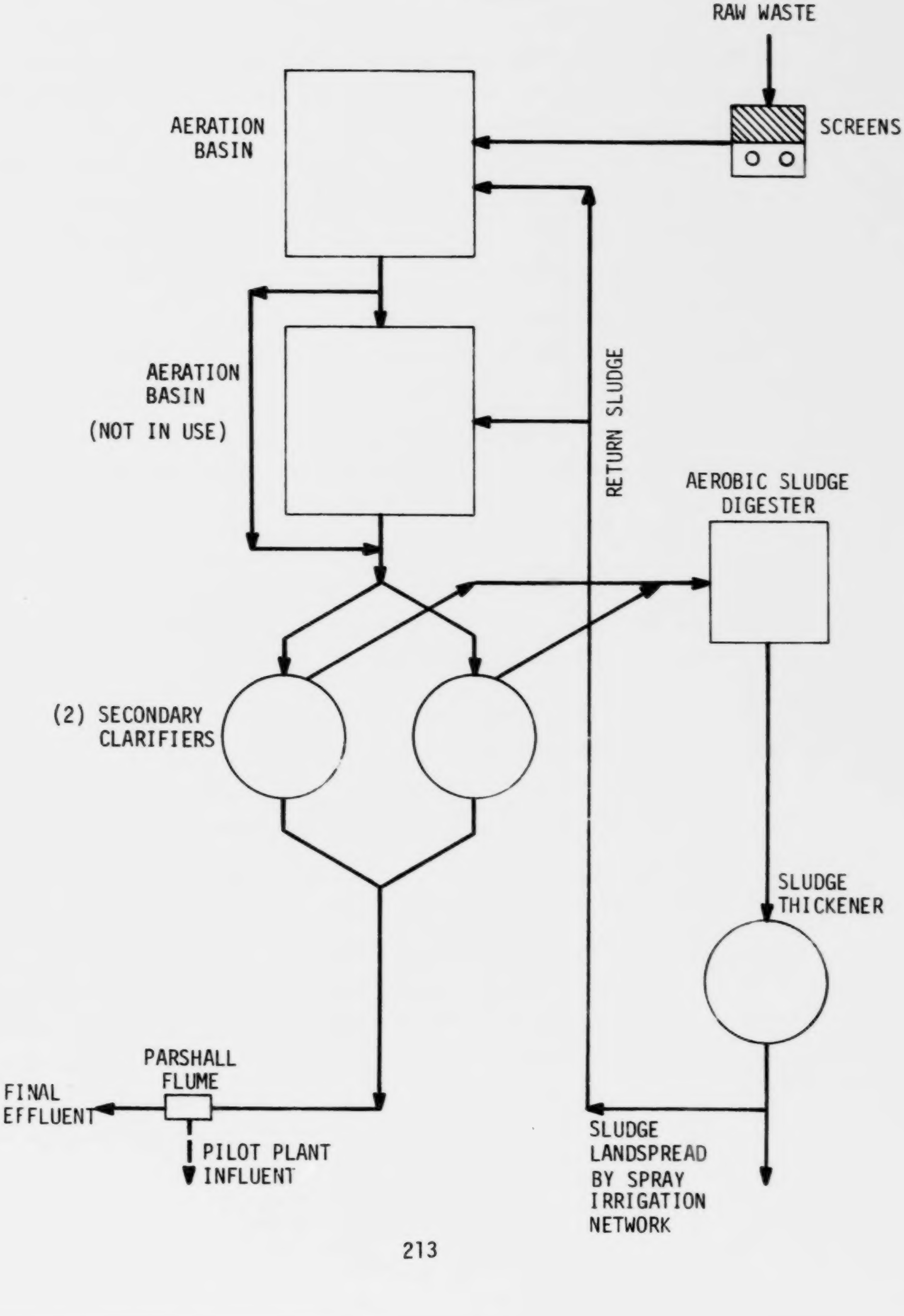
WATER USAGE

Based on total wastewater flow during the on-site study, 11.6 gallons of wastewater was generated per pound of finished material produced.

FIGURE C-9(Z)

SCHEMATIC FLOW DIAGRAM WASTEWATER

TREATMENT FACILITIES - PLANT Z


RAW WASTE
SCREENS
AERATION BASIN
AERATION BASIN
(NOT IN USE)
RETURN SLUDGE
AEROBIC SLUDGE DIGESTER
(2) SECONDARY CLARIFIERS
SLUDGE THICKENER
PARSHALL FLUME
FINAL EFFLUENT
PILOT PLANT INFLUENT
SLUDGE LANDSPREAD BY SPRAY IRRIGATION NETWORK

PLANT AA

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant AA, a Subcategory IV (Woven Fabric Finishing) and Subcategory V (Knit Fabric Finishing) plant. The objectives of this pilot plant study are to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant AA, determine the effectiveness of the technologies for achieving the BATEA guideline limitations and define the mutually (ATMI, EPA and ES) agreed upon recommendations for the most cost-effective treatment process(es).

Existing wastewater treatment facilities at Plant AA include neutralization, equilization, screens, aeration basins, and secondary clarifiers.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations.

CONCLUSIONS

1. The existing wastewater treatment facility at Plant AA was not meeting Best Practicable Technology (BPT) guideline effluent limitations for BOD_5 and TSS.

2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations, additional treatment beyond BPT is required for BOD_5, COD, TSS, and Color removal (based on observations made during pilot plant operations).

3. The following observations and conclusions were made based on the pilot scale screening experiments at Plant AA.

   a. Clarifier and Multi-Media Filter (Mode A) - Jar tests conducted in the ES Atlanta Laboratory prior to initiation of trailer operations indicated that either American Cyanamid 572C (cationic polymer) or lime in conjunction with the polymer would be effective coagulants. However, on-site verification tests revealed that waste characteristics were quite variable and these coagulants were not suitable. Extensive further testing was performed on-site, but a suitable coagulant was not found. Therefore, Mode A experiments were not conducted during the screening phase of on-site work. At the outset of the candidate mode evaluations, jar test results showed either American Cyanamid 572C or Nalco 8100 to be possibly effective coagulants, however, Mode A was not selected for operation during the candidate mode phase because of the variable nature of the BPT effluent coagulant demand, the high coagulant dosages required, and the fact that filtration was an efficient unit process for solids removal during screening tests.

b. Multi-Media Filter and Carbon Columns (Mode B) - Multi-media filtration provided 49% TSS removal at the optimum loading rate of 3 gpm/ft^2. High BPT effluent TSS concentrations resulted in high filter effluent TSS values. Little COD and color reduction occurred as a result of filtration. The carbon columns provided 56% soluble COD reduction and considerable color reduction.

c. Multi-Media Filter and Ozonation (Mode C) - Again, the multi-media filter provided reasonable TSS removal. Ozone was applied in dosages ranging from 0 to 419 mg/l O_3 utilized, or 0 to 1.6 lb O_3/lb COD. Color reduction was essentially complete at 150 mg/l O_3, while soluble COD reduction at this dosage was 42%.

d. Multi-Media Filter with Precoagulation (Mode F) - These tests were conducted with a cationic polymer, (Hercules 855) at 0.5 mg/l dosage as a filter aid. As compared to Mode B filter tests (no filter aid), greater TSS and COD reductions were obtained. Filter run times of 12 hours were obtained with 81% TSS removal and 35% COD removal.

e. Dissolved Air Flotation (Mode G) - Two sets of batch tests were conducted using a coagulant (Cyanamid 572C) at three recycle rates (100%, 50%, 33%). Although significant TSS (68%) and COD (32%) reductions were obtained during the first test series using a BPT effluent possessing a TSS concentration of 101 mg/l, no improvements were obtained during the second test series when the BPT effluent TSS concentration was 51 mg/l (normal effluent quality).

4. The two candidate BATEA process technologies for Plant AA showing the greatest potential for favorable treatment effectiveness are Mode M (Multi-media filtration with pre-filter coagulation followed by carbon adsorption) and Mode K (Multi-media filtration with pre-filter coagulation followed by ozonation).
5. Mode M met all BATEA effluent guideline limitations for the predicted long term average. Based on the projected 90th percentile effluent values, Mode M met all guideline values except COD. Mode M effluent exceeded BATEA COD limitations by 13%. Mode K met all BATEA limitations except COD (by 32%) for the long term average. The BATEA COD limitation was exceeded by 43% based on the projected 90th percentile value for Mode K. Both process technologies met all maximum day BATEA effluent limitations based on projected 99th percentile effluent values.

RECOMMENDATIONS

1. The recommended BATEA treatment process for Plant AA is Multi-media filtration with pre-filter coagulation followed by carbon adsorption (Mode M). The projected effluent quality for this process, based on the results of this study, will achieve all BATEA effluent guideline values except COD for the 30-day average. Mode M was selected based on the fact that it came closer to meeting the BATEA effluent COD limit than the other treatment process tested during candidate operations.
2. The recommended filter loading is 3 gpm/ft^2 using 0.5 mg/l cationic polymer (Hercules 855) as a pre-filter coagulant. Carbon column empty bed hydraulic detention time should be 45 minutes. The carbon capacity is 0.103 lb soluble COD/lb carbon. Process design criteria are presented in Chapter VI.

PLANT AA

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the waste treatment plant effluent from the Plant AA textile manufacturing facilities. Plant AA is a Subcategory IV (Woven Fabric Finishing) and Subcategory V (Knit Fabric Finishing) mill. The woven fabric finishing which comprises 73.5 percent of total production is a complex manufacturing operation using synthetic and blends of natural and synthetic filters. The knit fabric finishing operation accounts for the remaining 26.5 percent of plant production. The primary fiber used is polyester (100% and blended with cotton and rayon). Production processing includes desizing, scouring, bleaching, mercerizing and dyeing (Range, Becks, Jets). The sizing used at Plant AA is PVA. Special finishes include soil release and water repellent.

PRODUCTION DATA

The BATEA pilot plant was on-site at the Plant AA site for a 42-day period (February 17, 1978 through March 29, 1978). During this time the mill operated 34 days. The woven fabric finishing plant averaged 138,527 pounds per day of product while the knit fabric finishing plant averaged 49,934 pounds per day of production (see Appendix E). Finishing production totaled 6,407,572 pounds of material including 100% polyester, 65% polyester/35% cotton, 65% polyester/35% rayon, 80% polyester/20% rayon, 80% polyester/20% cotton and 90% polyester/10% cotton. The manufacturing plant reported a production capacity of 148,000 pounds per day woven fabric and 60,000 pounds per day knit fabric.

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant AA is presented in Figure C-10(AA). More specific process information is summarized in Table C-17(AA).

The incoming industrial raw waste passes through bar screens prior to entering a 600,000 gallon aerated, neutralization basin. Mixing is

TABLE C-17(AA)

PLANT AA

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow - 3.5 MGD
Normal Flow - 2.26 MGD
Flow During Pilot Experimentation - 2.41 MGD

Equalization - Neutralization

No. of Basins - 1
Basin Size - 0.60 MG
Detention Time - 4 hrs
Aeration - 1 - 40 HP; 67 HP/MG
H_2SO_4 Addition

Nutrient Addition

None

Screening

Bar Screens - 1.25"
Hydrosieves - 0.020 in openings - (3)

Aeration Basin

No. of Basins - 2 (one in use during pilot experimentation)
Volume (Total) - 7.2 MG
Aeration (Total) - 450 HP; 63 HP/MG
Detention Time - 49 hrs. at design flow
76 hrs. at normal flow
72 hrs. during pilot experimentation

Secondary Clarifiers

No. of Clarifiers - 2
Size: Diameter - 60 ft (inside diameter)
SWD - 10 ft
Recycle Rate - 3.0 MGD (total)

Other Facilities

Oxidation Pond (Domestic Waste; parallel to industrail waste treatment facility) facilitated with a power to volume ratio of 67 HP/MG. Sulfuric acid is fed to this basin for pH adjustment. Following neutralization the waste passes through three hydrasieve screens at a screen spacing of 0.020 inches. The waste is then split and diverted to two parallel aeration basins with a total volume of 7.2 MG at a power to volume ratio of 63 HP/MG and a detention time of 49 hours at design flow. Aeration is provided by floating low speed mechanical surface aerators. A typical mean cell residence time is 209 days. Aeration basin effluent is combined then diverted to two parallel 60-foot diameter secondary clarifiers.

The sanitary waste which is less than 1 percent of the total waste flow is treated separately by an oxidation pond. Effluent is combined with the industrial waste effluent prior to discharge to the receiving stream.

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data for the waste treatment plant as reported by the plant are shown in Appendix A for the one-year period immediately prior to and including the period of pilot plant study. The discharge values reported for the last year are compared to the Best Practicable Treatment (BPT) Guideline values in Table C-18(AA). The influent to the pilot plant trailer was collected from the manhole which included both secondary clarifier effluent and oxidation pond effluent.

According to the data presented in Table C-18(AA), the waste treatment plant is obtaining an overall BOD_5 removal efficiency of 93 percent. During the one year period prior to pilot plant arrival, the secondary plant effluent exceeded BPT guideline limitations for BOD_5, COD, and TSS for 30 day averages. Maximum day limits were exceeded for BOD_5, TSS and pH.

During the on-site visit by the pilot plant there were several production changes and treatment plant operational problems which significantly affected operation of the pilot plant process technologies. Some of the unusual production and waste treatment plant operational occurrences which influenced the pilot plant operation are noted below:

TABLE C-18(AA)

PLANT AA

COMPARISON OF ACTUAL PERFORMANCE TO BPT LIMITATIONS

	BPT EFFLUENT GUIDELINE LIMITATIONS				Actual Operation March '77 to March '78	
	lbs/day (1)		mg/l at 2.26 MGD (2)		mg/l	
Parameter	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.	30-Day Averages 3)	Max. Day 3)
BOD_5	582	1164	31	62	13-43(3)	28-79(3)
COD	10139	20279	538	1076	274-549(1)	385-927(0)
TSS	1777	3554	94	189	28-108(1)	37-239(2)
Phenol	9.5	18.9	0.50	1.00	.011-.032(0)	.015-.045(0)
Chromium	9.5	18.9	0.50	1.00	.004-.013(0)	.011-.023(0)
Sulfide	18.9	37.7	1.00	2.00	.02-.09(0)	0.1-0.2(0)
Color	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Flow	N.A.	N.A.	N.A.	N.A.	2.33-2.62	2.5-3.7
pH	6-9	6-9	6-9	6-9	7.2-7.8(0)	8.1-9.4(1)

(1) See Appendix E for Calculation of BPT Guidelines.

(2) Flow average as reported by the plant for the period March '77 to March '78.

(3) Number in parenthesis is the number of times BPT guideline was exceeded during the one-year period.

Notes on BPT Operations

3/4 - 3/7 A manufacturing plant caustic spill caused neutralization basin pH to reach 11.9.

3/8 Microscopic examination of mixed liquor showed a lack of normally abundant rotifiers and protozoa.

3/11 - 3/14 Noticable pin floc flowing over secondary clarifier weir.

3/16 Plant caustic spill increased raw pH to 11.5

3/17 Plant substituted acetic acid for sulfuric acid for pH control.

3/15 - 3/18 One aerator down in each basin.

3/20 Microscopic examination of mixed liquor indicated return of protozoa and rotifiers.

3/23 - 3/28 One aerator down in aeration basin.

Notes on BPT Effluent Quality

2/23 - 3/17 Color of Plant AA BPT effluent rust brown (29-35 %T @ 520 nm). Visable solids in secondary clarifier effluent.

3/17 - 3/19 BPT effluent became black in color (15-20 %T @ 520 nm). Immediate color breakthrough on pilot plant carbon columns. Increase in ozone demand for color removal.

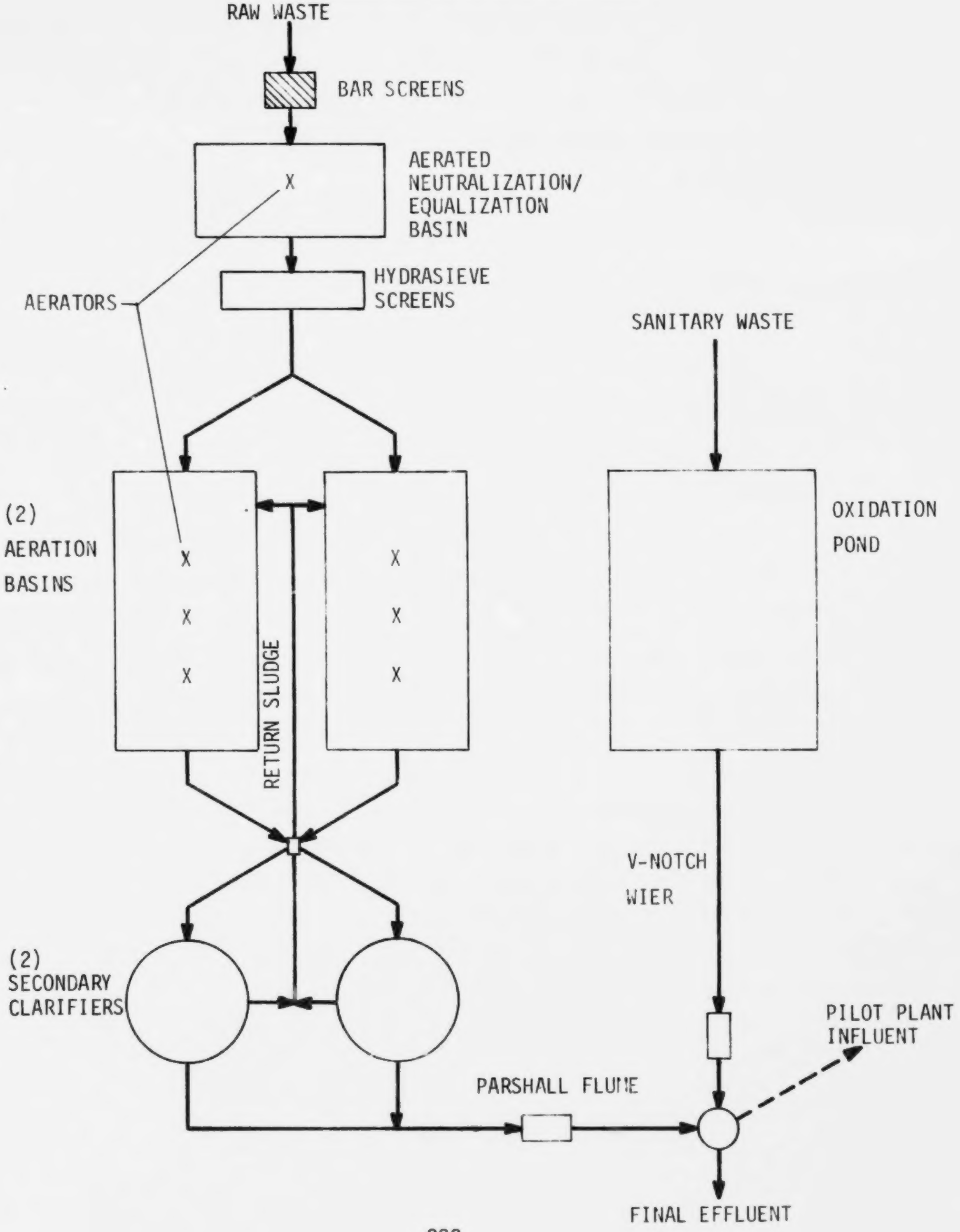
3/19 - 3/29 BPT effluent color still black, but not as intense (28-32 %T @ 520 nm). BPT effluent TSS decreased.

WATER USAGE

Based on an average wastewater flow of 2.41 MGD during the on-site study, 12.8 gallons of wastewater were generated per pound of finished material produced. This figure includes both woven fabric finishing and knit fabric finishing production.

FIGURE C-10(AA)

SCHEMATIC FLOW DIAGRAM - EXISTING WASTEWATER TREATMENT FACILITIES AT PLANT AA


RAW WASTE
BAR SCREENS
AERATED NEUTRALIZATION/ EQUALIZATION BASIN
AERATORS
HYDRASIEVE SCREENS
SANITARY WASTE
(2) AERATION BASINS
RETURN SLUDGE
OXIDATION POND
V-NOTCH WIER
(2) SECONDARY CLARIFIERS
PILOT PLANT INFLUENT
PARSHALL FLUME
FINAL EFFLUENT

PLANT BB

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant BB, a Subcategory IV, Woven Fabric Finishing plant. The objectives of this pilot plant study are to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant BB, determine the effectiveness of the technologies for achieving the BATEA guideline limitations and define the mutually (ATMI, EPA and ES) agreed upon recommendations for the most cost-effective treatment process(es).

Existing wastewater treatment facilities at Plant BB include an aerated equalization basin followed by an aeration basin. Final polishing is provided by a natural lagoon. Pilot plant experimentation was performed on aeration basin effluent.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations.

CONCLUSIONS

1. The existing wastewater facilities (equalization and aeration units) at Plant BB were achieving the Best Practicable Technology (BPT) guideline effluent limitations for all parameters during pilot plant experimentation.
2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations additional treatment beyond BPT is required to reduce TSS, COD and color.
3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant BB.
   a. Coagulation/Clarification Followed by Multi-Media Filtration (Mode A) - The optimum coagulant/dosage combination tested was alum at 120 mg/l Al^{+3} at a pH of 6.5. The reactor/clarifier reduced BOD_5, COD, Cr_T and TOC at all loadings tested. COD reduction was maximized at a reactor/clarifier loading at 100 gpd/ft^2. TSS concentrations

were increased across the clarifier at all loadings tested (100, 200, 300 and 400 gpd/ft^2) except 100 gpd/ft^2. The average reactor/clarifier influent and effluent TSS concentrations at this loading were about the same. Due to the low flow rate required to maintain 100 gpd/ft^2 on the clarifier, filter experimentation was limited to 1.5 gpm/ft^2. The multi-media filter, at this loading, provided additional 8% COD, 10% TSS and 10% TOC reductions over clarifier effluent.

b. Multi-Media Filtration Followed by Activated Carbon Contact (Mode B) - Multi-Media Filter experiments were done at loadings of 2, 3, 5 and 7 gpm/ft^2. It was found that 3 gpm/ft^2 was the most effective loading rate. The carbon columns were successful in removing 41% COD, 41% SOD, 17% TSS and 47% TOC from the multi-media filter effluent. Considerable color reduction was also noted.

c. Multi-Media Filtration Followed by Ozonation (Mode C) - Two Mode C batch experiments were done using multi-media filter effluent during operation at 3 gpm/ft^2 (most effective loading). Utilized dosages from 28 to 729 mg O_3/l were applied. Though considerable color reduction was observed, little organic removal was detected (11% COD reduction after 729 mg O_3/l utilized).

d. Multi-Media Filtration with Precoagulation (Mode F) - On-site jar tests showed visual threshold floc to be formed using alum at a dosage of 16 mg/l Al^{+3}. The addition of filter aid coagulant improved COD removal over straight filter operation. TSS, however, were higher in all cases in filter effluent than filter influent due to escaping floc.

e. Dissolved Air Flotation (Mode G) - Two dissolved air flotation (DAF) batch experiments were performed. Coagulant dosage used was 120 mg/l Al^{+3} at a pH of 6.5. Maximum COD reduction was 44% at 100% recycle. TSS, however, were increased in all cases from 50 to 670%.

4. The two candidate BATEA process technologies for Plant BB (those showing the greatest potential for favorable treatment effectiveness) are coagulation/clarification followed by multi-media filtration (Mode A) and multi-media filtration followed by activated carbon adsorption (Mode B).

5. Neither of the two candidate processes tested met all BATEA guideline levels. Mode A exceeded the BATEA guideline values for TSS by 89% (25 mg/l) for the 30-day average and 13% (7 mg/l) for the maximum day value. Mode B exceeded TSS by 11% (3 mg/l) and COD by 20% (38 mg/l) for the 30-day averages. Mode B met all limitations on the maximum day values.

6. Based on a relative cost comparison the economic superiority of one candidate treatment process over the other could not be established.

RECOMMENDATIONS

1. Multi-media filtration followed by granular carbon adsorption is the recommended BATEA process for Plant BB. The projected effleunt quality for this process will not achieve the BATEA guideline values for TSS or COD. Mode B was selected over Mode A because it provided an effluent which came closer to the BATEA guideline limitations.

2. The recommended multi-media filter surface loading rate is 3 gpm/ft^2 followed by a carbon column hydraulic residence time of 45 minutes. The carbon capacity loading is 0.14 lb soluble COD/lb carbon. Process design criteria are presented in Chapter VI.

PLANT BB

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the waste treatment plant effluent from the Plant BB textile manufacturing facility. Plant BB is a Subcategory IV (Woven Fabric Finishing) mill. One hundred percent of the production at Plant BB is classified as "commission finishing". Primary fibers used are nylon and dacron. Production processes include scouring, bleaching and dyeing. Printing also is done on a small portion of production (<5%). Special finishes include DWR, FR, CRF and polyurethane coatings.

PRODUCTION DATA

The BATEA pilot plant was operated at the Plant BB site for a 38-day period (August 23, 1978 through September 29, 1978). During this time, the plant operated for 29 days, averaging a production of 44,665 pounds of material per day (see Appendix E). Production during the pilot plant visit totaled 1,295,285 lbs. Production during the period was 72.5% nylon, 25.0% dacron with other materials comprising the remaining 2.5%. The manufacturing plant has a predicted capacity of 65,000 lbs/day.

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant BB is presented in Figure C-11(BB). More specific process information is summarized in Table C-19(BB).

The wastewater treatment plant influent is primarily industrial waste with the only sanitary waste being that generated in the manufacturig facility. Raw waste passes first through an aerated equalization basin (1.7 day H.D.T.). Oxygen transfer and mixing is provided by a 15 HP surface type aerator. In the past a second aerator has been added at times to help reduce odors from the equalization basin. The aeration basin provides a 280 hour H.D.T. Aeration and mixing is accomplished with 5 surface type aerators (total power imput = 85 HP). The power to volume ratio for the basin is 15.5 HP/MG. Flow from the aeration basin passes

TABLE C-19(BB)

PLANT BB

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow = 0.47 MGD

Normal Flow = 0.612

Flow During Pilot Experimentation = 0.577

Influent BOD_5 - 390 mg/l

Equalization

Aerated: Volume - 0.8 MG
Aeration - 15 HP; 18.8 HP/MG

Neutralization

None

Nutrient Addition

None

Screening

None

Aeration Basin

No. of Basins - 1

Basin Volume - 5.5 MG

Aeration - 85 HP (surface aerators); 15.5 HP/MG

Design detention time - 280 hr.

Detention time at normal flow - 216 hr.

Detention time during pilot experimentation - 229 hr.

Secondary Clarifiers

None

Other Operations

Polishing Pond: BPT effluent discharges into a 3-4 MG natural pond before entering receiving stream. Pilot plant operations were done on aeration basin effluent prior to pond.

through a natural lagoon before entering the receiving river. Pilot plant operations were done on the aeration basin effluent.

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data of the waste treatment plant as reported by the plant are shown in Appendix A for the 13 month period immediately prior to and including the period of the pilot study. The discharge values reported for the last year are compared to the Best Practicable Treatment (BPT) Guideline values in Table C-20(BB).

Based on the data presented in Table C-20(BB) and the influent BOD_5 value from Table C-19(BB), the wastewater treatment plant is obtaining BOD_5 removal efficiencies of 78-96%. Based on data reported by Plant BB the wastewater treatment facility exceeded BPT limits for BOD_5 three months during the period Aug. '77 - Aug. '78. For all other pollutants BPT limits were not exceeded. It should be noted, however, that the data presented in Table C-20(BB) is based on one 8-hr. composite sample per month. The true 30-day average could be considerably different.

There were no operational upsets at the wastewater treatment plant that effected pilot plant operations.

TREATMENT PLANT INFLUENT VARIABILITY

During the period of pilot plant study, the textile manufacturing plant generally operated 5-6 days per week. This variability is not reflected in the overall statistical treatment of the data in this report, since only days when data were available were included. During periods of low flow the aeration basin has enough retention time to maintain a suitable biological population. The mean cell retention time cannot be estimated based on insufficient plant data.

WATER USAGE

Based on an average wastewater flow of 0.577 MGD during the on-site study, 12.9 gallons of wastewater were generated per pound of finished material produced.

TABLE C-20(BB)

PLANT BB

COMPARISON OF ACTUAL PERFORMANCE WITH BPT GUIDELINE VALUES

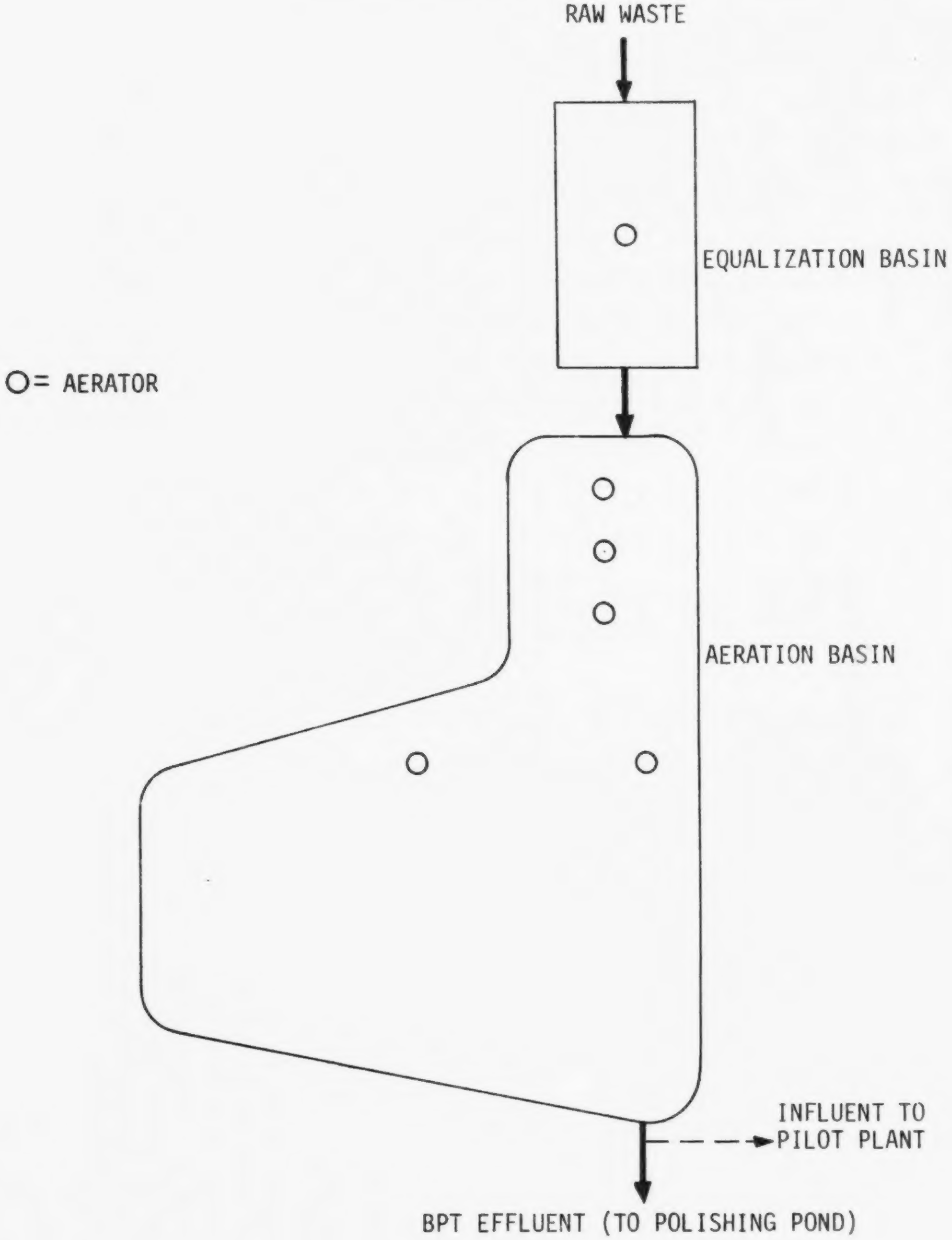
	BPT Guideline Values				Actual Operation(3)		
	lbs/day (1)		mg/1 at 0.612 MGD(2)		Aug. '77 - Aug. '78 mg/1		
PARAMETER	30-DAY AVG.	DAILY MAX.	30-DAY AVG.	DAILY MAX.	30-DAY AVG.	(5)	DAILY MAX.
BOD_5	295	590	58	116	17-87	(3)	-
COD	2680	5360	525	1050	378(4)		-
TSS	795	1590	156	312	11-87	(0)	-
Phenol	4.47	8.93	0.88	1.75	0.005-0.21	(0)	-
Chromium	4.47	8.93	0.88	1.75	0.15 -0.20	(0)	-
Sulfide	8.93	17.87	1.75	3.50	0.005-1.17	(0)	-
Flow, (MGD)	n.a.	n.a.	n.a.	n.a.	0.459-0.907		-
pH, (unitless)	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0	7.0-7.5	(0)	9.0

---

(1) See Appendix E for the calculations of the BPT Guideline Values.
(2) Average flow for the period of August '77 through August '78 as reported by the plant.
(3) Based on one measurement per month except for pH.
(4) COD not measured by plant. Value reported is average of observations during pilot plant visit.
(5) Number in parenthesis indicates number of months when BPT limitations were exceeded.
n.a. Not applicable.

FIGURE C-11(BB)

SCHEMATIC DIAGRAM - EXISTING WASTEWATER TREATMENT FACILITIES AT PLANT BB


RAW WASTE
EQUALIZATION BASIN
○= AERATOR
AERATION BASIN
INFLUENT TO PILOT PLANT
BPT EFFLUENT (TO POLISHING POND)

PLANT DD

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant DD, a combination of a Subcategory D (IV) Woven Fabric Finishing Plant and a Subcategory G (VII) Stock and Yarn Dyeing and Finishing Plant. This was the initial field experimental study. During this site visit the shakedown of the pilot plant equipment was conducted and the experimental program was refined and modified.

The objectives of this plant study are to evaluate the potential BATEA technologies for treating the BPT effluent of Plant DD, determine the effectiveness of the technologies for meeting the proposed BATEA effluent limitations, and define the mutually (ATMI, EPA and ES) agreed upon recommendation for the most cost-effective treatment process(es).

Existing wastewater treatment facilities at Plant DD include screens, neutralization, aeration, secondary clarification, chlorination and sludge drying beds for sludge dewatering. The experimental testing was performed on the secondary clarifier effluent prior to chlorination.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations:

CONCLUSIONS

1. The existing wastewater treatment facilities at Plant DD were effectively treating the textile plant wastewater and producing an effluent quality that met the Best Practical Technology (BPT) guideline limitations.
2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations additional treatment beyond BPT is required to reduce the COD and TSS.
3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant DD:
   a. Coagulation/Clarification Followed By Multi-Media Filtration (Mode A) - Jar tests were conducted in which ferric chloride with anionic polymer and alum were selected as the optimum coagulants. In the pilot-scale tests neither coagulant used

with the reactor/clarifier functioned well and in four experiments an increase in TSS was observed. The multi-media filter reduced the applied TSS by as much as 90 percent and was somewhat effective for organic reduction (BOD_5, COD and TOC).

b. Multi-Media Filtration Followed By Granular Carbon Adsorption (Mode B) - The multi-media filter reduced TSS by 35 to 75 percent when the applied TSS was above 10 mg/l. Organic removal was not very significant across the filter. The optimum surface loading rate for the multi-media filter was 2 gpm/ft^2. The carbon columns reduced COD, TOC, TSS and chromium. The COD reduction through the carbon columns varied between 40 and 60 percent which indicates a relatively high non-adsorbable fraction of COD present in the effluent.

c. Multi-Media Filtration Followed By Ozonation (Mode C) - During this experiment the suspended solids concentration of the BPT effluent was extremely low, 3 mg/l or less. Therefore, the function of the filter in the process train was insignificant. Ozone was not effective in providing BOD_5 and COD reduction, but did reduce the color.

d. Ozonation (Mode D) - Ozonation at the dosages tested was not effective for BOD_5 and COD reduction, but did reduce the color.

e. Multi-Media Filtration With Precoagulation (Mode F) - Precoagulation of the multi-media filter influent with 12 mg/l alum as Al^{+3} enhanced the performance of the filter. The filter not only provided TSS reductions of 40 to 89 percent, but also demonstrated good performance for COD, chromium and color reduction. The optimum surface loading rate was 2 gpm/ft^2.

f. Dissolved Air Flotation (Mode G) - Dissolved air flotation (DAF) was not effective for suspended solids removal. Because of the low concentration of suspended solids in the BPT effluent and the addition of coagulants, the DAF effluent suspended solids were greater than the influent suspended solids.

4. The two candidate BATEA processes (those showing greatest potential for favorable cost-effectiveness) for Plant DD are multi-media filtration followed by granular carbon adsorption (Mode B) and multimedia filtration with precoagulation (Mode F).

5. The two candidate BATEA processes, Modes B and F, produced a similar effluent quality and both processes were effective for achieving the BATEA effluent limitations for all parameters except TSS and BOD_5. The BATEA guideline value for TSS was 6 mg/l and the projected TSS for Mode B was 16 mg/l and for Mode F was 14 mg/l. Mode F achieved the BATEA guideline value for BOD_5, but Mode B exceeded the guideline value of 8 mg/l by 3 mg/l.

6. Comparative capital cost and operating and maintenance cost indicate that Mode F is significantly less expensive than Mode B.

RECOMMENDATIONS

1. Multi-media filtration with precoagulation is the recommended BATEA process for Plant DD. The projected effluent quality from this process does not achieve the BATEA guideline value for TSS. However, this process produced an effluent quality better than or equal to the other technologies evaluated. Multi-media filtration is more cost-effective than the alternate candidate process, filtration and granular carbon adsorption.

2. The recommended design loading for the multi-media filter is 2 gpm/ft^2 with a coagulant dosage of 12 mg/l alum (as Al^{+3}). Process design criteria are presented in Chapter VI.

PLANT DD

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the waste treatment plant effluent from the two manufacturing plants that comprise the Plant DD manufacturing facility. One facility is classified as a Subcategory VII plant (Stock and Yarn Dyeing and Finishing), the other as a Subcategory IV plant (Woven Fabric Finishing, complex manufacturing). The primary fibers used are cotton and blends of dacron, nylon and cotton. The production processing includes desizing (starch), scouring, bleaching, mercerizing, and dyeing (package and continuous).

PRODUCTION DATA

The BATEA pilot plant was operated for a 61-day period (May 9, 1977 through July 8, 1977) at this site. The finishing production during this same 61-day period totaled 8,072,019 pounds of material. The production during the days the plant was operating averaged 179,898 pounds per day (see letter in Appendix E). Finished materials included 100% cotton, 65% polyester/35% cotton, and textured polyester. The manufacturing plants have a capacity of approximately 60,000 pounds/day stock and yarn and 167,000 pounds/day woven fabric finishing.

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant DD is presented in Figure C-12(DD). More specific process information is summarized in Table C-21(DD).

The raw wastewater from the two manufacturing facilities are combined prior to treatment. The incoming waste is first screened by a 2-inch bar screen to remove objects such as cloth, paper, plastic, wood, etc. The influent is normally alkaline, therefore, neutralization consists of acid addition before the waste enters the aeration basin. The aeration basin has a volume of 12 million gallons which provides a detention time of 48 hours. Aeration is provided by fixed and floating mechanical surface aerators at a power to volume ratio of 87.5 HP/MG. Following aeration, the

TABLE C-21(DD)

PLANT DD

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow - 6 MGD (approximately 10% sanitary waste)

Influent BOD_5 - 220 mg/l or 11,000 lb/day

Equalization

None

Neutralization

Acid addition

Nutrient Addition

None

Screening

Bar Screens - 2 inch

Aeration Basin

No. of Basins - 1
Basin Size - 12 MG
Aeration - 1050 HP (surface aerators); 87.5 HP/MG.
Detention Time- 48 hours

Secondary Clarifiers

No. of Clarifiers - 2
Size: Diameter - 90 ft.
Side Water Depth - 12 ft.
Recycle rate - 5 MGD (total)

Other Operations

Chlorination
Sludge Drying Beds

bio-solids are separated from the water in the two final clarifiers. Sludge is returned to the aeration basin or may be transferred to a sludge holding basin as required to maintain the desired concentration of suspended solids in the aeration basin. The mean cell retention time is approximately 150-300 days. The waste sludge is dewatered in sludge drying beds. The clarified effluent is chlorinated prior to discharge into the receiving stream.

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data of the waste treatment plant as reported by the plant are shown in Appendix A for the one-year period immediately prior to and including the period of the pilot study. Daily operating data as reported by the plant are also presented in Appendix A for the period the pilot studies were in progress. The discharge values reported for the last year are compared to the Best Practical Treatment (BPT) Guideline values in Table C-22(DD). The influent to pilot plant trailer was collected from the secondary clarifier effluent prior to chlorination.

Based on the data presented in Table C-22(DD), and Appendix A, the waste treatment plant is obtaining an overall BOD_5 removal efficiency of 98 percent and is achieving the BPT guideline values for all parameters.

It should be noted that during the major portion of the on-site visit there were operational/control problems with the Plant DD treatment facility. The two most significant problems were:

1) the failure of the sludge wasting line to the existing sludge drying bed, and

2) the pumping schedule from the most remote manufacturing facility to the common waste treatment plant.

These two factors combined to produce hydraulic surges and periods when excess (waste) activated sludge could not be wasted. These periods were typified by excessive solids loss over the weirs. During these "upset" periods the solids concentration in the clarifier effluent was too high to allow effective operation of the mobile pilot plant.

TABLE C-22(DD)

PLANT DD

COMPARISON OF ACTUAL PERFORMANCE TO BPT GUIDELINE VALUES

Parameter	BPT Guideline Values				Actual Operation Aug. '76 - July '77	
	lbs/day[1]		mg/l at 6 MGD[2]		mg/1	
	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.	Avg.	Max.
BOD_5	598	1195	12	24	4.7	11
COD	9237	18475	185	369	129	280
TSS	1593	3186	32	64	26	50
Phenol	9.40	18.8	0.188	0.376	0.067	0.10
Chromium	9.40	18.8	0.188	0.376	0.176	0.80
Sulfide	18.8	37.6	0.376	0.751	n.m.	n.m.
Color, (Pt-Co units)	n.a.	n.a.	n.a.	n.a.	(97)	(800)
Flow, (MGD)	n.a.	n.a.	n.a.	n.a.	6.06 MGD	7.6 MGD
pH, (unitless)	(6.0-9.0)	(6.0-9.0)			(6.3-8.9)	

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(1) See Appendix E for the calculations of the BPT Guideline Values

(2) The average flow for the period of August '76 thru July '77 was reported by the plant as 6.06 MGD

n.m. = not monitored by mill laboratory

n.a. = not applicable

TREATMENT PLANT INFLUENT VARIABILITY

During the period the pilot plant studies were underway, the textile manufacturing plants generally operated five days per week. This variability is not reflected in the overall statistical treatment of the data in this report, as only days where data was available were included. The treatment plant, as discussed earlier, has a hydraulic retention time in the aeration basin of 48 hours at a flow rate of 6 MGD. This capacity serves effectively with recycle of sludge (clarifier underflow) to maintain the biological population during periods of low flow.

WATER USAGE

Based on an average wastewater flow of 5.4 MGD during the on-site study, 30.0 gallons of wastewater was generated per pound of finished material produced. This figure includes both the Stock and Yarn plant and the Woven Fabric Finishing plant less the 10 percent municipal waste contribution.

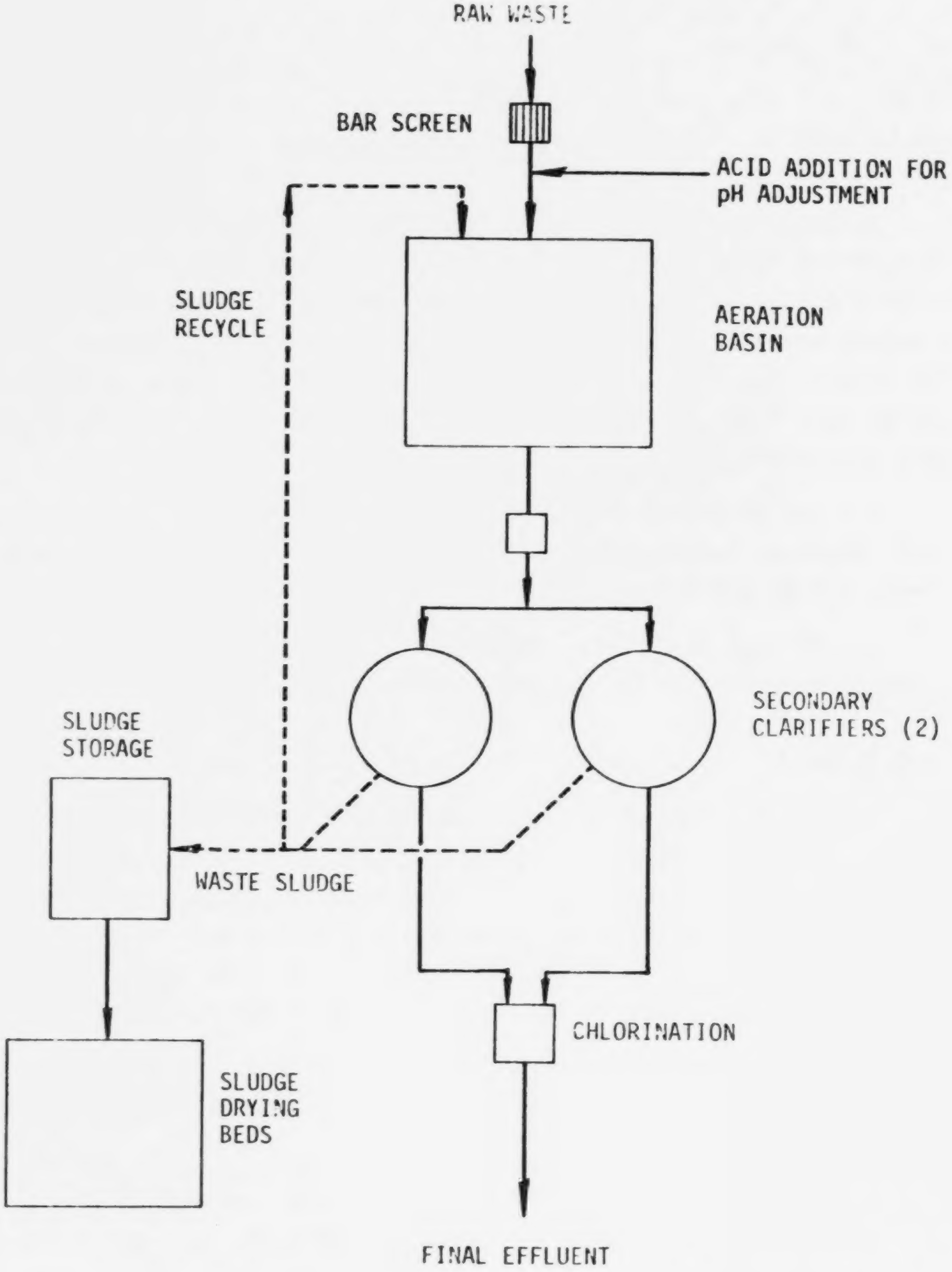

RAW WASTE
BAR SCREEN
ACID ADDITION FOR pH ADJUSTMENT
SLUDGE RECYCLE
AERATION BASIN
SECONDARY CLARIFIERS (2)
SLUDGE STORAGE
WASTE SLUDGE
CHLORINATION
SLUDGE DRYING BEDS
FINAL EFFLUENT

FIGURE C-12(DD)

SCHEMATIC FLOW DIAGRAM-EXISTING WASTEWATER TREATMENT FACILITIES AT PLANT DD

PLANT T

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant T, a Subcategory IV, Woven Fabric Finishing Plant. The objectives of this pilot plant study are to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant T, determine the effectiveness of the technologies for achieving the BATEA guideline limitations and define the mutually (ATMI, EPA and ES) agreed upon recommendations for the most cost-effective treatment process(es).

Existing wastewater treatment facilities at Plant T include equalization, aeration, secondary clarification, a polishing pond, step reaeration, sludge storage and aerobic sludge digestion.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations.

CONCLUSIONS

1. The existing wastewater facilities at Plant T were achieving the Best Practical Technology (BPT) guideline effluent limitations during the period the pilot plant study was conducted. Historically (12 month period just prior to pilot plant visit) Plant T has consistantly met all BPT effluent limitations except those for TSS (on both 30-day averages and daily maximum basis).
2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations additional treatment beyond BPT is required to reduce COD and TSS.
3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant T:
    a. Reactor/Clarifier and Multi-Media Filter (Mode A) - Jar tests indicated that none of the coagulants tested were effective at coagulation of this wastewater. Therefore, Mode A experiments were not conducted during the screening phase of on-site work.

b. Multi-Media Filter with Carbon Columns (Mode B) - The multimedia filter was operated at surface loading rates of 3.0, 5.0 and 7.0 gpm/ft^2. At a filter loading rate of 5.0 gpm/ft^2 the filter achieved 35% TSS removal as well as reducing BOD_5, total COD and TOC. The carbon columns were operated at a 45 minute (total) hydraulic retention time. During the screening experiments the Mode B process removed an average (for all experiments) of 71% BOD_5 (from 17 mg/l to 5 mg/l), 38% total COD (from 622 mg/l to 388 mg/l), 34% soluble COD (from 548 mg/l to 362 mg/l), 63% TSS (from 24 mg/l to 9 mg/l), 41% sulfide (from 1.23 mg/l to 0.73 mg/l), as well as providing good color removal (from 60% to 90% transmittance). Total COD reduction through the carbon columns varied from 25% to 55%.

c. Multi-Media Filter and Ozonation (Mode C) - The multi-media filter was operated at a surface loading rate of 3.0 gpm/ft^2 and achieved a TSS removal of 50%. Ozone was applied in dosages ranging from 18 mg/l to 72 mg/l ozone utilized. Excellent color removal was exhibited but little or no organic reduction was achieved.

d. Multi-Media Filter with Precoagulation (Mode F) - The multimedia filter was operated at surface loading rates of 3.0, 5.0 and 7.0 gpm/ft^2 with alum precoagulation at a dosage of 10 mg/l as Al^{+3}. The multi-media filter with precoagulation was not as effective at TSS removal as straight filtration (Mode B) and the filter run times (time between backwashing) were less.

e. Dissolved Air Flotation (Mode G) - Dissolved Air Flotation (DAF) experiments were performed at several recycle rates (100%, 75%, 50% and 33%). BOD_5 removal was noted, but reduction in the other measured pollutants was not significant or consistant.

4. The candidate BATEA process technology showing the greatest potential for favorable treatment effectiveness at Plant T is multi-media filtration followed by carbon adsorption (Mode B).

5. Mode B achieved the BATEA BOD_5, phenol, sulfide and color guideline values for Plant T, but did not meet the BATEA COD and TSS guidelines. The BATEA guideline value for TSS is 14 mg/l and the projected TSS for Mode B is 19 mg/l. The BATEA COD value is 179 mg/l while Mode B has a projected COD value of 474 mg/l.

RECOMMENDATIONS

1. Multi-Media Filtration Followed by Carbon Adsorption (Mode B) is the recommended BATEA process at Plant T. The projected effluent quality from this process does not achieve the BATEA guidelines for COD or TSS. However, Mode B produced an effluent quality better than the other technologies in terms of COD.

2. The recommended design surface loading rate for the multi-media filter is 5 gpm/ft^2. Carbon column hydraulic residence time should be 60 minutes. The carbon capacity loading is 0.112 gm soluble COD/gm carbon. Process design criteria are presented in Chapter VI.

PLANT T

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were conducted on the waste treatment plant effluent from the two manufacturing complexes that comprise the Plant T manufacturing facility, a Subcategory IV (Woven Fabric Finishing) Plant. One complex is composed of four greige mills, a batting mill and a cotton warehouse. The greige mills operations involve spinning and weaving of natural, synthetic and blends of natural/synthetic and synthetic fibers. The other complex is involved in production processes including desizing, scouring, bleaching, mercerizing, dyeing and printing of the greige goods manufactured at the greige mills. The primary fibers used are cotton, polyester and rayon.

PRODUCTION DATA

The BATEA pilot plant was at this site for a 50-day period (June 8, 1978 through July 27, 1978) during which the pilot plant was shutdown on weekends and for a 9-day period spanning the July 4 holiday. The production data during this time totaled 25,785,585 pounds. During the 35 days the plant operated, production averaged 736,731 pounds per day. The manufacturing plant has a maximum processing capacity of approximately 750,000 lbs/day. (See Appendix E). The primary fiber used was a 65%/35% polyester cotton blend (88.5%) with other fibers used including 100% cotton, 100% polyester and blends of 40%/60% polyester cotton, 50%/50% polyester cotton and 65%/35% polyester rayon. The major process involved is scouring and bleaching (100%); others involved are mercerizing (27.9%), dyeing (61.8%) and printing (30.8%). The greige mills also discharge to the wastewater treatment plant. The average production for the four mills totals approximately 85,000 pounds per day (included in the 736,731 lb/day production average).

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant T is presented in Figure C-13(T). More specific process information is summarized in Table C-23(T). The raw wastewater from the greige mills (average flow approximately .104 MGD total) is pretreated in stablization ponds, then combined with the raw wastewater from the finishing plant prior to treatment. The incoming waste is first passed through bar screens prior to entering the equalization basin. After equalization the waste enters the aeration basins. The three aeration basins, with a total volume of 15.0 million gallons, provide a total detention time of 30.0 hours at design flow. Aeration is provided by surface aerators at a power to volume ratio of 120 HP/MG. Following aeration, the bio-solids are separated from the water in four final clarifiers. Sludge is returned to the aeration basins or pumped to the aerobic sludge digestor. The waste sludge is stabilized in the 29 MG sludge basin. The sludge age ranged between 12.4 and 27.5 days for the one year period prior to pilot plant arrival based on information provided Plant T. Average sludge age for the period was 18.2 days. The supernatant from the secondary clarifiers flow by gravity through a flow measuring devise into a 35 MG polishing pond. The final effluent from the polishing pond flows through a second Parshall Flume, down a step aeration spillway and is discharged to the receiving stream via underwater diffusers.

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data of the waste treatment plant, as reported by the plant, are shown in Appendix A for the one-year period immediately prior to and including the period of the pilot study. Daily operating data as reported by the plant are also presented in Appendix A for the period the pilot studies were in progress. The discharge values reported for the last year are compared to the calculated BPT values in Table C-24(T). The effluent values reported in this table are from the secondary clarifier. The pilot plant trailer operated on the secondary clarifier effluent which was upstream of the polishing pond. The clarifier effluent quality is also presented in Appendix A.

During the on-site experimental study there were no major effluent quality upsets created by production changes or biological treatment operational problems. Some unusual production and waste treatment plant

TABLE C-23(T)

PLANT T

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow - 12.0 MGD

Flow During Pilot Plant Visit - 8.72 MGD

Equalization

No. of Basins - 1
Basin Size - 10.0 MG
Detention Time - 20 hours (at design flow)
28 hours (during pilot plant visit)

Nutrient Addition

Anhydrous Ammonia

Screening

Bar Screens - 1-in (parallel, vertical)

Aeration Basin

No. of Basins - 3
Volume (Total) - 5.0 MG/Basin = 15. MG
Aeration - 1800 HP; 120 HP/MG
Detention Time - 30.0 hours (at design flow
41.3 (during pilot plant operations)

Secondary Clarifiers

No. of Clarifiers - 4
Size: Diameter - 2-90 ft; 2-110 ft.
Side Water Depth - 10 ft.; 12 ft.
Recycle Rate - 9 to 12 MGD (total)

Sludge Handling Facilities

Aerobic Sludge Digestor - 2.5 MG
Sludge Holding Pond - 14.0 MG
Sludge Basin - 29 MG

Other Facilities

Magnetic Flow Meter (influent)
Parshall flume (effluent)
Polishing pond
Step Reaeration Spillway

TABLE C-24(T)

PLANT T

COMPARISON OF ACTUAL PERFORMANCE WITH BPT GUIDELINE VALUES

	BPT Guideline Values(1)				Actual Operation August '77 - July '78	
	lbs.day		mg/1 at 8.13 MGD(2)		Range(3) mg/1	
PARAMETER	30-DAY AVG.	DAILY MAX.	30-DAY AVG.	DAILY MAX.	30-DAY AVG.	DAILY MAX.(4)
BOD_5	2151	4301	32	63	8.9 - 12 (0)	12 - 17 (0)
COD	38935	77869	574	1148	499 - 546 (0)	696 - 1120 (0)
TSS	5800	11601	86	171	15 - 143 (3)	32 - 396 (5)
Phenol	32.6	65.2	0.48	0.96	0.02 - 0.03 (0)	0.04 (0)
Chromium	32.6	65.2	0.48	0.96	n.m.	n.m.
Sulfide	65.2	130.3	0.96	1.92	0.07 - 0.15 (0)	0.64 - 0.80 (0)
pH	Shall range between 6.0 and 9.0				7.0 - 8.5 (0)	7.7 - 13 (0)
Color	Shall not exceed 300 ADMI				96 - 101 (0)	160 - 240 (0)

(1) See Appendix E for the calculations of BPT Guideline Values.
(2) The average flow for the period August, 1977 through July, 1978 was reported by the plant aa 8.13 MGD.
(3) Range of 30-day Avg. X - X (number of occurrances above BPT guideline values).
(4) Range of Daily Maximum (number of months with values above BPT guideline limitations).
n.a. not applicable.
n.m. not measured.

operation occurrences that influenced the pilot plant operation are noted below:

- June 15, 1978 - TSS in BPT effluent increased due to production change.
- June 27, 1978 - Slight clarifier upset during the night.
- June 30 - July 9, 1978 - Plant production facilities were shutdown for holiday.
- July 10, 1978 - Plant resumed production, however, the flow through the waste treatment plant was too low to begin pilot plant operation.

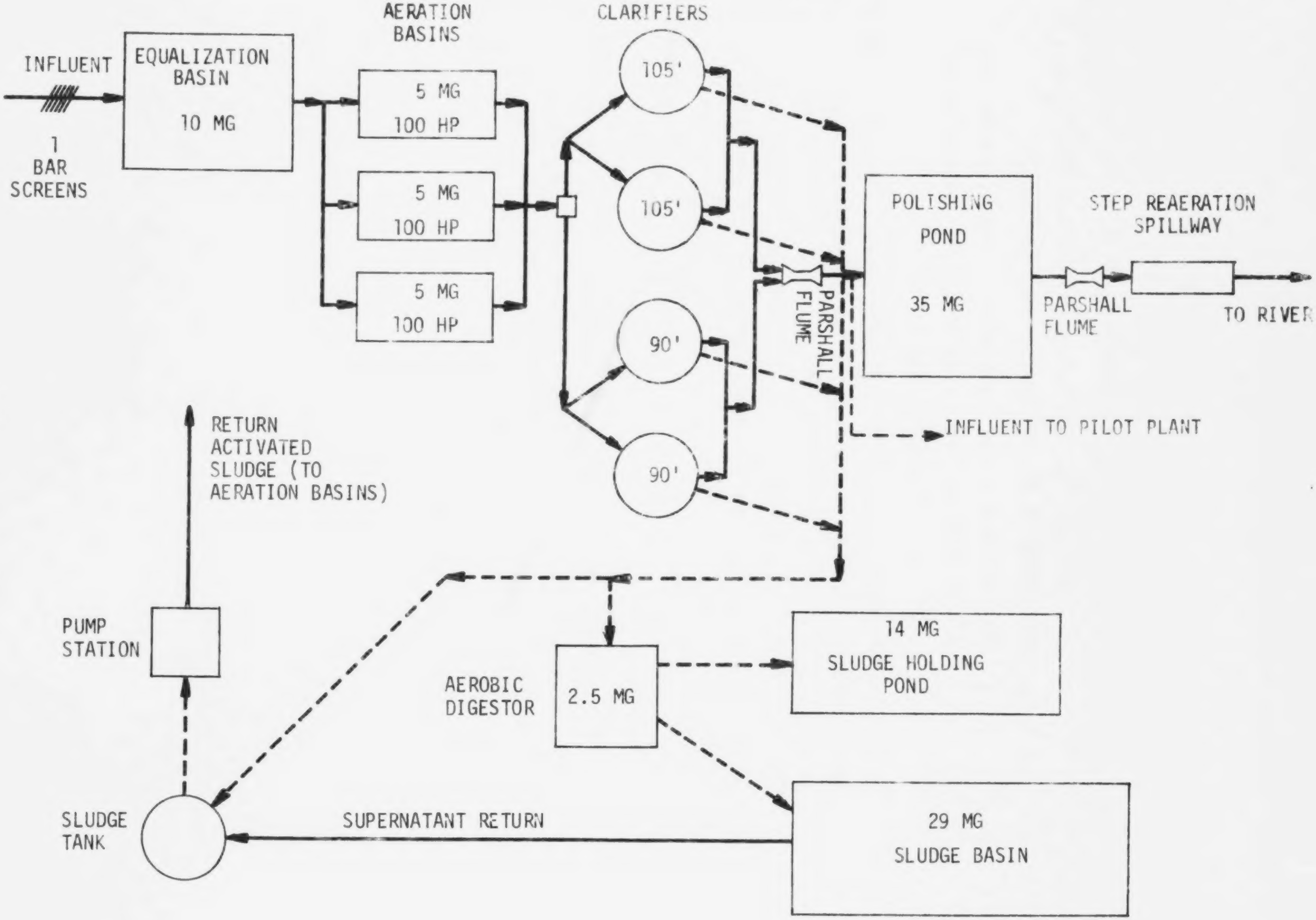
During the past year, three monthly averages of clarifier effluent data exceeded the BPT TSS limits. The plant had limited sludge wasting capabilities for a four month period in which clarifier TSS were elevated. Construction of a sludge holding pond was underway to alleviate these TSS upsets. BOD_5, COD, chromium, phenol, sulfide, pH and color were all within the BPT guidelines during the 12-month historical period.

WATER USAGE

Based on an average wastewater flow of 8.72 MGD during the on-site study, 13.4 gallons of wastewater was generated per pound of finished material produced.

FIGURE C-13(T)

SCHEMATIC FLOW DIAGRAM - EXISTING WASTEWATER TREATMENT FACILITIES AT PLANT T


AERATION BASINS
CLARIFIERS
INFLUENT
EQUALIZATION BASIN
10 MG
1 BAR SCREENS
5 MG
100 HP
5 MG
100 HP
5 MG
100 HP
105'
105'
90'
90'
PARSHALL FLUME
POLISHING POND
35 MG
STEP REAERATION SPILLWAY
PARSHALL FLUME
TO RIVER
INFLUENT TO PILOT PLANT
RETURN ACTIVATED SLUDGE (TO AERATION BASINS)
PUMP STATION
AEROBIC DIGESTOR
2.5 MG
14 MG
SLUDGE HOLDING POND
SLUDGE TANK
SUPERNATANT RETURN
29 MG
SLUDGE BASIN

PLANT K

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant K, a Subcategory IV, Woven Fabric Finishing plant. The objectives of this pilot plant study are to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant K, determine the effectiveness of the technologies for achieving the BATEA guideline limitations and define the mutually (ATMI, EPA and ES) agreed upon recommendations for the most cost-effective treatment process(es).

Existing wastewater treatment facilities at Plant K include screening, aeration basin, secondary clarification, chlorination, and sludge drying beds. The experimental testing was performed on the secondary clarifier effluent prior to chlorination.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations.

CONCLUSIONS

1. The existing wastewater facilities at Plant K were achieving the Best Practicable Technology (BPT) guideline effluent limitations for all parameters during the period the pilot plant study was conducted.
2. To achieve the BATEA effluent limitations additional treatment beyond BPT is required to reduce color.
3. Based on the pilot experimentation period, Plant K's production differs from most Subcategory IV plants in that only a minor portion of the total production (32%) is dyed on-site. Also no sizing is done at Plant K and thus no desizing waste must be treated. These factors could account for the relatively low level of treatment required to meet the BATEA effluent limitations.
4. The following observations and conclusions were made from the pilot scale screening experiments at Plant K:

a. Reactor/Clarifier and Multi-Media Filter (Mode A) - A variety of metallic coagulants and combinations of coagulants as well as cationic polymers were jar tested for effectiveness in transmittance improvement, turbidity reduction, and minimal sludge production. Alum at 30 mg/l (as Al^{+3}) at a pH of 7.0 was determined to be the most overall effective coagulant for use with Mode A. This dosage was utilized with the reactor/clarifier at overflow rates of 400, 600 and 700 gpd/ft^2. The optimum loading was found to be 600 gpd/ft^2. The reactor/clarifier effectively removed all measured pollutants except TSS which increased due to floc carry over.

The multi-media filter was operated at loading rates of 3, 5, and 7 gpm/ft^2 with 5 gpm/ft^2 found to be the optimum. Overall, Mode A at 600 gpd/ft^2 and 5 gpm/ft^2 achieved an effluent quality of 6 mg/l BOD_5, 34 mg/l COD, 17 mg/l TSS, and <.01 mg/l chromium. Color removal was indicated by an increase in % transmittance from 57 to 91%.

b. Multi-Media Filtration Followed by Activated Carbon Contact (Mode B) - The multi-media filter was operated at loading rates of 3, 5, and 7 gpm/ft^2. 5 gpm/ft^2 was found to be the most effective. The carbon columns were operated at 45 minutes hydraulic residence time and were not exhausted during the screening phase of the study. Utilizing ICI Hydrodarco granular carbon preceded by the multi-media filter operated at a loading rate of 5 gpm/ft^2 the effluent quality achieved was 7 mg/l BOD, 12 mg/l COD, 2 mg/l TSS, and <.02 mg/l chromium. Color removal increased % transmittance from 48 to 96%.

c. Multi-Media Filtration Followed by Ozonation (Mode C) - The Mode C batch tests were conducted with effluent from the multi-media filter during operation at a surface loading rate of 7 gpm/ft^2. Ozone dosages ranged from 8 to 104 mg/l ozone utilized. At 8 mg/l ozone utiled, typical Mode C effluent quality was 21 mg/l BOD_5 (an increase from filter effluent at 15 mg/l), 47 mg/l COD, 2 mg/l TSS, .01 mg/l chromium, and 97 percent transmittance.

d. Multi-Media Filtration with Precoagulation (Mode F) - Results of jar test performed with a variety of coagulants showed 6 to 8 mg/l Ferric Chloride (as Fe^{+3}) to be the visual threshold floc formation dosage for use as a filter aid. Optimum filter performance was achieved at a loading rate of 2 gpm/ft^2. Mode F operation exhibited slightly better COD reduction than achieved with Mode B (no precoagulation) due to $FeCl_3$ addition. Color removal was also enhanced. Effluent quality achieved with Mode F was 9 mg/l BOD_5, 43 mg/l COD, 6 mg/l TSS, .016 mg/l chromium and 70 percent transmittance (an increase from 56 percent).

e. Dissolved Air Flotation (Mode G) - Bench-scale dissolved air flotation experiments were performed at 100%, 50% and 33% recycle, utilizing 30 mg/l alum at a pH of 7.0 as a coagulant. The 50% recycle was most effective providing a typical effluent quality of 40 mg/l COD, 10 mg/l TSS, 0.05 mg/l chromium and 81 percent transmittance. BPT effluent was treated to BATEA guideline limits with Mode G (coagulation/dissolved air flotation). Mode G was not evaluated as a candidate process, however, because of limitations for collecting sufficient comparitive data with the batch experimental DAF unit.

4. The candidate process technologies showing the greatest potential for favorable treatment effectiveness for Plant K were multi-media filtration followed by carbon columns (Mode B), multi-media filtration followed by ozonation (Mode C), and multi-media filtration with precoagulation (Mode F).

5. The three candidate modes achieved all the BATEA effluent guideline values.

6. A comparison of the capital costs and the operating and maintenance costs indicate that the three modes, Multi-Media Filtration with Precoagulation was the most cost effective BATEA treatment process.

RECOMMENDATIONS

1. Multi-media filtration with precoagulation is the recommended BATEA process for Plant K. The projected effluent quality for this process will acheive all BATEA guideline values.
2. The recommended operating conditions for the BATEA process are as follows:

   Filter Loading Rate - 2 gpm/ft^2
   Coagulation - $FeCl_3$ at 16 mg Fe^{+3}/l
   Caustic addition as needed for final pH adjustment.

   Process design criteria are presented in Chapter VI.

PLANT K

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the wastewater treatment plant effluent from Plant K. Plant K is classified as a Subcategory IV (Woven Fabric Finishing) plant. The plant is involved in the dyeing, finishing and application of special finishes (approximately 60% of produced goods are latex backed). Primary materials involved are cotton and rayon, with polyester, 50% polyester/50% cotton, and 60% rayon/40% cotton blends also utilized.

Plant K, during pilot experimentation, was only dyeing 32% of the total production on-site (piece dyeing). The remaining 68% was dyed elsewhere (yarn dyeing). No sizing was being done at all, therefore the raw wastewater contained no desizing waste. These factors make Plant K atypical of most Subcategory IV plants.

PRODUCTION DATA

The BATEA pilot plant was operated for a 32-day period (August 1, 1978 through September 1, 1978) at Plant K. Total production during this period was 1,099,616 pounds. Average daily production for Plant K was 34,363 pounds per day. The production capacity as reported by the mill is 43,000 pounds per day (See Appendix E).

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant K is presented in Figure C-14(K). More specific process information is summarized in Table C-25(K).

The raw process wastewater from the woven fabric faciltiy is combined with the sanitary wastewater from the plant, which comprises approximately 5% of total wastewater volume. The combined waste is pumped through 3/4" bar screens prior to entering the aeration basin. The volume of the aeration basin is 6 million gallons which provides a detention time of 3 days at design flow. However, the actual flow is approximately an order of magnitude less than design flow, hence the aeration basin provides a max-

TABLE C-25(K)

PLANT K

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow = 2.0 MGD

Normal Flow = 0.33 MGD

Flow During Pilot Operations = 0.17

Equalization
None

Neutralization
None

Nutrient Addition
None

Screening

3/4" Bar Screens

Aeration Basin

Basin Size - 6.0 MG

Aeration (Total) - 225 HP

Detention Time - 72 hours (at design flow)
436 hours (at normal flow)
847 hours (during pilot operations)

Secondary Clarifiers

Number of Clarifiers - 1

Size: Diameter - 80 feet

SWD - 9 feet

Recycle Rate -

Other Operations

Chlorination

Sludge Drying Beds

imum detention time of about 35 days. Aeration is provided by 9-25 HP floating surface aerators which provide a power to volume ratio of 37.5 HP/MG. Following aeration, the bio-solids are separated from the water in an 80 foot diameter final clarifier. Sludge is returned to the aeration basin or may be wasted to sludge drying beds as required to maintain the desired concentration of suspended solids in the aeration basin. Presently all sludge is being returned to the aeration basin. The clarified effluent is chlorinated prior to discharge into the receiving stream. Flow for pilot plant experimentation was taken prior to chlorination.

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data of the waste treatment plant, as reported by Plant K, are shown in Appendix A for the one-year period immediately prior to and including the period of the pilot study. Daily operating data, as reported by the plant, are also presented in Appendix A. This data covers the period during which the pilot studies were in progress. The discharge values reported for the last year are compared to the BPT guideline values in Table C-26(K). The effluent values reported in this table are final effluent numbers.

Plant K experienced no serious operational problems during the pilot plant visit.

Based on the monthly averages over a twelve month period (July 1977 to June 1978), the plant was achieving average effluent values of 5 mg/l BOD_5, 115 mg/l COD, and 22 mg/l TSS. No influent values were reported by the plant. During the same twelve month period, based on the data presented in Table C-26(K) and Appendix E, the plant was within the BPT guidelines for all parameters. The mean cell residence time could not be calculated due to insufficient plant data.

WATER USAGE

Based on an average wastewater flow of 0.17 MGD during the on-site study, two gallons of wastewater were generated per pound of finished material produced. This is minimal due to the production conditions during the study wherein production was 32.2% piece dyed and 67.8% yarn dyed fabric with no desizing as all fabrics are produced with plied yarn.

TABLE C-26(K)

PLANT K

COMPARISON OF ACTUAL PERFORMANCE WITH BPT GUIDELINE VALUES

	BPT Guideline Values(1)				Actual Operation July '77 - June '78 mg/l	
	lbs/day		mg/l at 0.33 MGD(2)		Range(3)	Range(4)
Parameter	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.	30-Day Avg.	Monthly Max.
BOD_5	113	227	41	82	1.4 - 12 (0)	2 - 17 (0)
COD	1698	3396	617	1234	75 - 216 (0)	75 - 216 (0)
TSS	306	612	111	222	11 - 47 (0)	18 - 59 (0)
Phenol	1.72	3.44	.62	1.25	.01 - .09 (0)	.01 - .09 (0)
Chromium	1.72	3.44	.62	1.25		
Sulfide	3.44	6.87	1.25	2.50	n.m.	n.m.
Color	N.A.	N.A.	N.A.	N.A.	310 - 780(5)	310 - 780(5)
Flow	N.A.	N.A.	N.A.	N.A.	.15 - .74	.44 - 1.27
pH	(6.0 - 9.0)		(6.0 - 9.0)		6.7 - 6.9 (0)	7 - 7.6 (0)

---

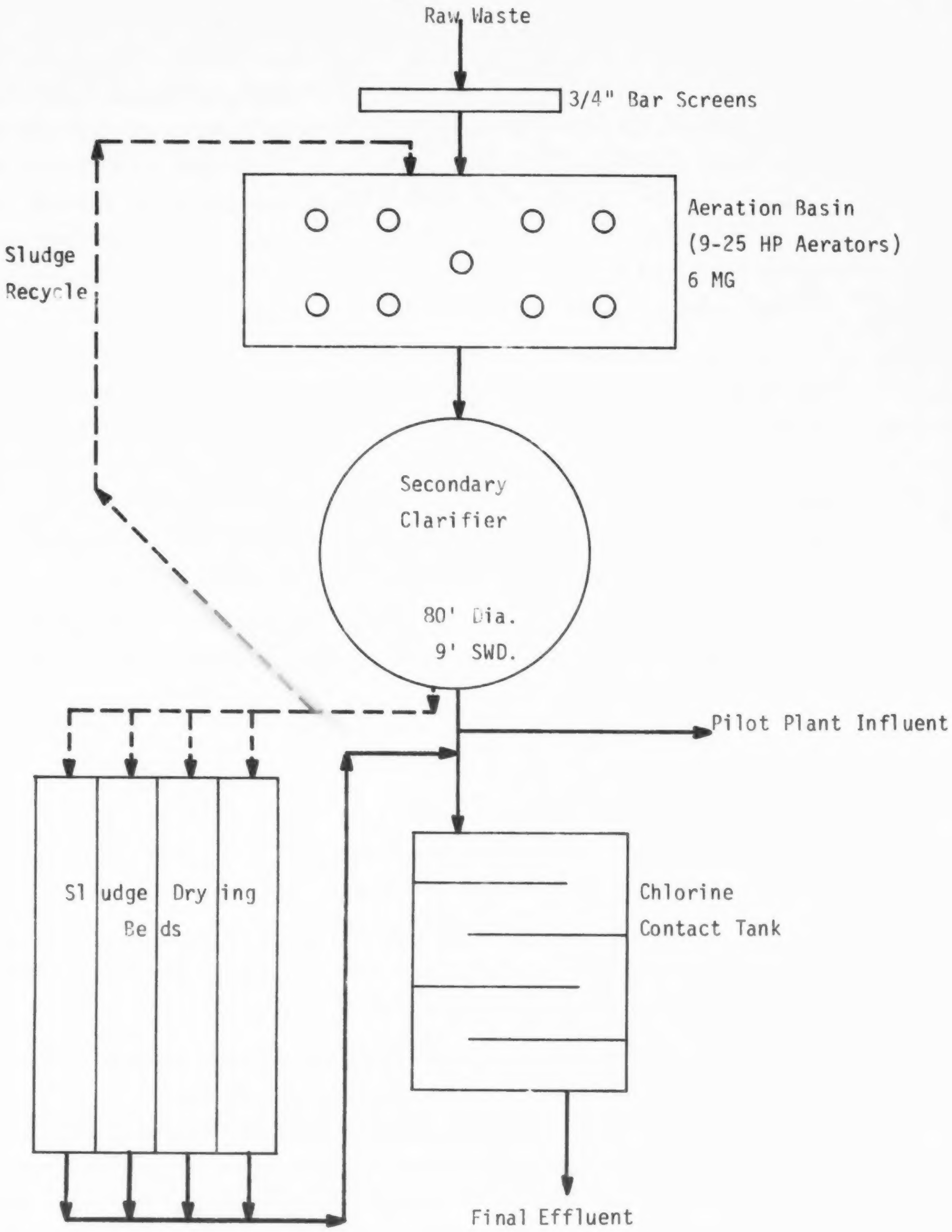
(1) See Appendix E for the calculations of BPT Guideline Values.
(2) The average flow for the period July 1977 through June 1978 was reported by the plant as 0.33 MGD.
(3) Range of 30-Day Average X - X {number of occurrances above BPT guideline values}.
(4) Monthly Maximum Range {number of months with values above BPT daily maximum guideline limitations}.
(5) Color was reported by plant in Platinum-Cobalt units.

N.A. = Not Applicable n.m. = Not Monitored

FIGURE C-14(K)

SCHEMATIC FLOW DIAGRAM
EXISTING WASTEWATER TREATMENT FACILITIES

PLANT K


Raw Waste
3/4" Bar Screens
Aeration Basin
(9-25 HP Aerators)
6 MG
Sludge
Recycle
Secondary
Clarifier
80' Dia.
9' SWD.
Pilot Plant Influent
Sludge Drying
Beds
Chlorine
Contact Tank
Final Effluent

PLANT W

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant W, a Subcategory V, Knit Fabric Finishing plant. The objectives of this pilot plant study are to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant W, determine the effectiveness of the technologies for achieving the BATEA guideline limitations and define the mutually (ATMI, EPA and ES) agreed upon recommendations for the most cost-effective treatment process(es).

Existing wastewater treatment facilities operated at Plant W during the plant visit included a gravity separation tank, an equalization basin, an aeration basin, a secondary clarifier, chlorination and sludge holding beds. The plant also had other treatment facilities which were not in service. These facilities included air flotation and distillation processes for recovery of solvents used in the printing process and vibrating screens for solids removal in the raw waste.

The information generated during this experimental study and presented in this report forms the basis for the following conclusions and recommendations.

CONCLUSIONS

1. The existing wastewater facilities at Plant W were achieving the Best Practical Technology (BPT) guideline effluent limitations during the period the pilot plant study was conducted.
2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations additional treatment beyond BPT is required to reduce BOD_5 and TSS.
3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant W.
    a. Coagulation/Clarification followed by Multi-Media Filtration (Mode A) - The reactor/clarifier effectively reduced TSS, COD and some color from the BPT effluent at the lower overflow rates. TSS removal was not achieved at the 600 and

800 gpd/ft^2 loadings. BOD_5 removal was not significant because the BOD_5 level of the BPT effluent was less than 4 mg/l. The optimum coagulant was American Cyanamid 572C at 10 mg/l. The most effective performance was achieved at an overflow rate of 400 gpd/ft^2. The multi-media filter provided additional removal of COD, TSS and color and was most effective at a surface loading rate of 3.0 gpm/ft^2. Total overall removals under the optimum conditions were 45 percent BOD_5, 53 percent COD, 40 percent TOC, 94 percent TSS and 15 percent color.

b. Multi-Media Filtration followed by Activated Carbon Adsorption (Mode B) - The multi-media filter reduced the TSS level to less than 10 mg/l at all surface loading rates. The filter also reduced COD. Filter effluent quality was not significantly different at the 3, 5 or 7 gpm/ft^2 surface loading rate. The carbon columns further reduced the levels of COD and color. Total Mode B reductions include 74 percent BOD_5, 84 percent COD, 74 percent TOC, 97 percent TSS and 19 percent color at the most effective loading rates.

c. Multi-Media Filtration followed by Ozonation (Mode C) - The Mode C batch tests were conducted with effluent from the multi-media filter operating at a surface loading rate of 7.0 gpm/ft^2. Ozone dosages ranged from 14 to 182 mg/l ozone utilized. The COD level was reduced by approximately 20 percent although the reduction was not significantly affected by the dosage in the range tested.

d. Multi-Media Filtration with Precoagulation (Mode F) - The multi-media filter was operated with 3 to 4 mg/l American Cyanamid 572C as a pre-filter aid. At a surface loading rate of 2.7 gpm/ft^2 the filter was effective in reducing COD (53 percent), TSS (94 percent) and color (23 percent), but was not able to remove TOC. At a surface loading rate of 4.1 gpm/ft^2 and 4 mg/l coagulant the filter achieved removals of 56 percent BOD_5, 42 percent COD, 67 percent TSS and 10 percent color.

e. Dissolved Air Flotation (Mode G) - Three bench-scale dissolved air flotation (DAF) experiments were conducted at 33.3, 50 and 100 percent recycle rates. The removal results were comparable to reactor clarification results. At 100 percent recycle removals of 46 percent COD and 35 percent TSS were obtained.

4. The three candidate BATEA process technologies for Plant W showing the greatest potential for favorable treatment effectiveness are multi-media filtration followed by activated carbon (Mode B), multi-media filtration with precoagulation (Mode F) and multi-media filter without precoagulation (Mode I).

5. Of the three candidate process technologies tested, Mode F was not able to meet the BATEA TSS guideline but met those for BOD_5, COD and color. Mode I met all parameters except TSS which was only 1 mg/l over the limit. Mode B met all the BATEA guideline parameters.

RECOMMENDATIONS

1. Mutli-media filtration (without precoagulation) is the recommended BATEA process for Plant W. The projected effluent quality for this process met all BATEA guideline values except TSS at the 7 gpm/ft^2 surface loading rate. The BATEA guideline value for TSS is 11 mg/l and the projected TSS effluent value is 12 mg/l.

2. It is recommended that the multi-media filter be designed at a surface loading rate of 5 gpm/ft^2 instead of 7 gpm/ft^2. At the reduced surface loading rate this should enhance the possibility of achieving the BATEA effluent value for TSS. Process design criteria in Chapter VI is based on the 5 gpm/ft^2 loading.

PLANT W

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the waste treatment plant effluent of the Plant W textile manufacturing facility, a Subcategory V (Knit Fabric Finishing) Plant. This plant is involved in a complex manufacturing operation involving natural, synthetic and blends of synthetic fibers. The primary fibers used are cotton, polyester, SEF, Kohjin and nylon. SEF and Kohjin are special flame retardant fibers. Production processes used at Plant W are bleaching, scouring, dyeing, printing and the application of chemical finishes.

PRODUCTION DATA

The BATEA pilot plant was at the Plant W site for a 42-day period (March 16, 1978 through April 26, 1978). The production during the same period totaled 1,243,632 pounds of material. The production during the 24 days the plant was operating averaged 51,818 pounds/day (see letter in Appendix E). The daily plant capacity was reported as 60,000 pounds. Materials included 100% cotton, 100% polyester, 100% Kohjin, 65% SEF/35% polyester, and 82% Kohjin/18% nylon. No unusual manufacturing occurences were reported by the plant during the pilot plant operations.

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant W is presented in Figure C-15(W). More specific process information is summarized in Table C-27(W). Plant W includes the treatment of two main process effluents, bleaching and dyeing, and printing. The stream from the print process goes first to an air flotation tank which at present is being used for gravity separation to settle out the heavy fluids and pastes. (An alternate route is also available for the air flotation effluent which passes it through a distillation column for solvent recovery. However, this unit is not in use at present.) The print wastewater then leaves the separation tank, joins the bleach and dye process stream and both streams pass through bar screens into the

TABLE C-27(W)

PLANT W

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow - 0.92 MGD

Equalization

No. of Basins - 1
Basin Size - 61,000 gals
Unaerated

Neutralization

None

Nutrient Addition

Nitrogen

Screening

Bar Screens - 1-3/4" O.C.

Aeration Basin

No. of Basins - 1
Volume (Total) - 2.7 MG
Aeration (Total) - 100 HP: 37 HP/MG
Detention Time - 72 hrs

Secondary Clarifiers

No. of Clarifiers - 1
Size: Diameter - 46 ft diameter
Side Water Depth - 8 ft
Recycle Rate - 0.3 MGD (total)

Other Facilities

Chlorination
Sludge Holding Basins
Air Flotation - available but not in use
Distillation Column - available but not in use
Vibrating Screens - available but not in use

equalization basin where nitrogen is added as a nutrient. Although they are not in service, the plant has vibrating screens for use following the equalization basin. After leaving the equalization basin the wastewater flows into an aeration basin with a total volume of 27 million gallons and a detention time of 72 hours. Aeration is provided by surface aerators at a power to volume ratio of 37 HP/MG. Following aeration, the biosolids are separated from the water in the final clarifier. Sludge from the clarifier is either returned to the aeration basins or pumped to sludge holding beds. The supernatant from the secondary clarifiers is chlorinated and discharged.

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data of the waste treatment plant, as reported by the plant, are shown in Appendix A for the one-year period immediately prior to and including the period of the pilot study. Daily operating data, as reported by the plant, are also presented in Appendix A for the period the pilot studies were in progress. The discharge values reported for the last year are compared to the BPT guideline values in Table C-28(W). The effluent values reported in this table are final effluent numbers. The pilot plant trailer operated on the secondary clarifier effluent prior to chlorination.

Based on the data presented in Appendix A, Plant W is presently achieving, on the average, 90% BOD_5 reduction with 70% COD removal. However, the data in Table C-28(W) reveals five instances during the 12-month period prior to and including the pilot plant study where the Plant W BPT effluent was not meeting the BPT guidelines. The monthly BOD_5 average was above the limit twice and three TSS monthly averages fell outside the BPT guideline. In one case, the monthly TSS average was 145 mg/l, almost two times the BPT TSS guideline value of 73 mg/l. The daily maximum TSS guidelines were exceeded six times and the maximum for BOD_5 was exceeded four times. The sludge age ranges from approximately 40 to 170 days.

Some production occurrences that influenced the pilot plant operation are noted below:

- April 4, 10, 12, 17 - plant clarifier experienced upset.

TABLE C-28(W)

PLANT W

COMPARISON OF ACTUAL PERFORMANCE WITH BPT GUIDELINE VALUES

Parameter	BPT Guideline Values				Actual Operation May '77-Apr.'78	
	lbs/day$^{(1)}$		mg/l at 0.933$^{(2)}$		mg/l	
	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.	Avg.*( )^{3}	Max.*( )^{3}
BOD_5 (mg/l)	130	259	17	33	4-41(2)	9-93$^{(4)}$
COD (mg/l)	1820	3640	234	468	86-227(0)	148-543$^{(1)}$
TSS (mg/l)	565	1130	73	145	40-142(3)	86-364$^{(6)}$
Phenol	2.59	5.18	0.33	0.67	n.m.	n.m.
Chromium	2.59	5.18	0.33	0.67	n.m.	n.m.
Sulfide	5.18	10.36	0.67	1.33	n.m.	n.m.
Flow (MGD)	n.a.	n.a.	n.a.	n.a.	0.772-1.057	0.968-2.378
pH	. . . . . . Within range of 6.0 to 9.0				7.1-7.5	7.4-8.0

(1) See Appendix E for the calculations of the BPT Guideline Values.

(2) Average flow for the period of May '77 through April '78 as reported by the plant.

(3) The figures in parentheses represent the number of months in the 12 month period in which the plant monthly average or maximum values exceed the BPT guidelines.

* These figures represent the range of the monthly average values as reported by the plant.

n.a. not applicable

n.m. not measured

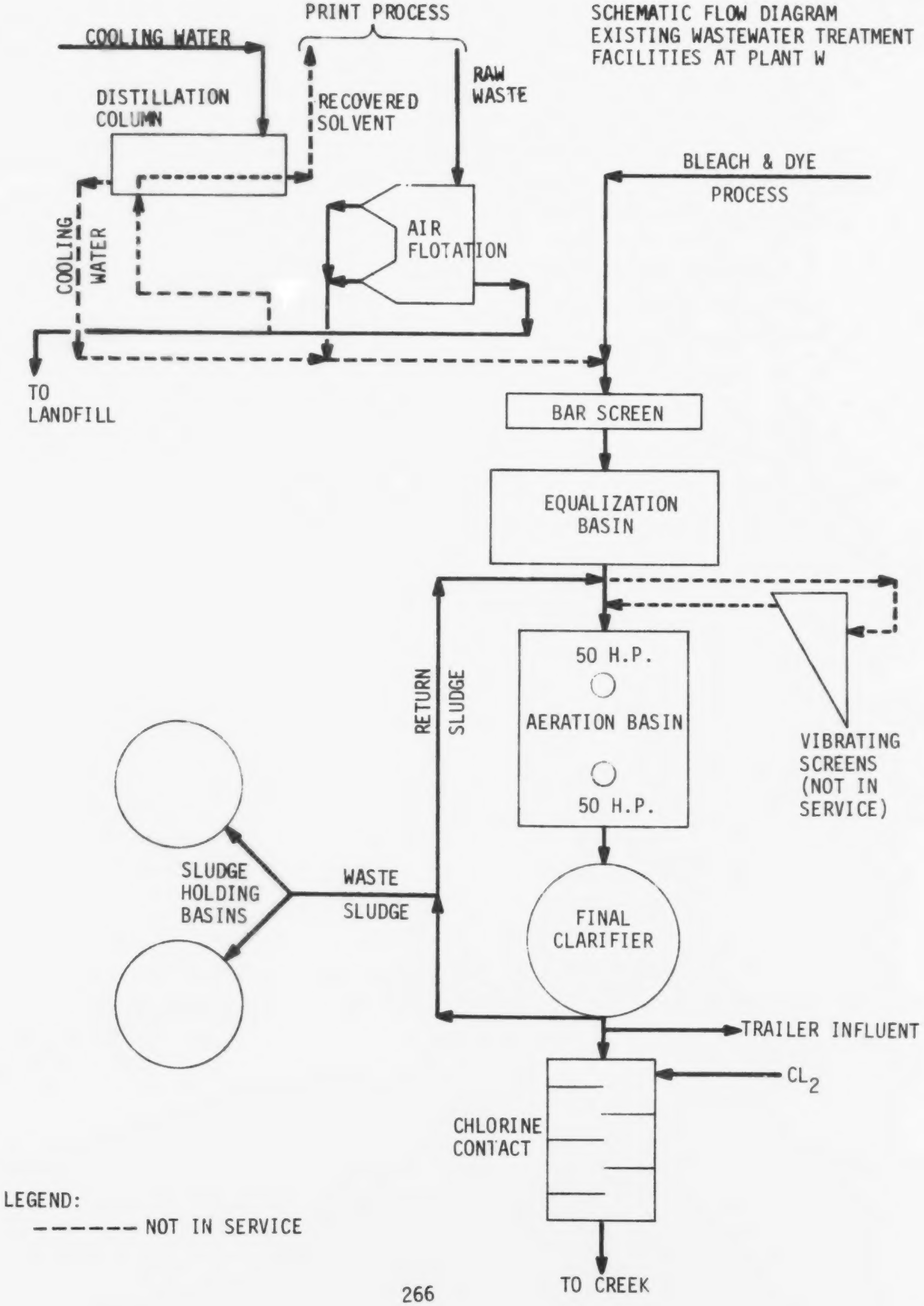
- April 18, 21 - high solids concentration in BPT plant effluent.
- The plant production facilities were in operation Monday through Friday and shut down on the weekends and holidays. Plant production was down for a total of 13 days during the Beta trailer visit.

WATER USAGE

Based on an average wastewater flow of 0.944 MGD during the on-site study, 18.2 gallons of wastewater were generated per pound of finished material produced.

FIGURE C-15(W)

SCHEMATIC FLOW DIAGRAM
EXISTING WASTEWATER TREATMENT
FACILITIES AT PLANT W


PRINT PROCESS
COOLING WATER
DISTILLATION COLUMN
RECOVERED SOLVENT
RAW WASTE
BLEACH & DYE
PROCESS
AIR FLOTATION
COOLING WATER
TO LANDFILL
BAR SCREEN
EQUALIZATION BASIN
50 H.P.
AERATION BASIN
50 H.P.
VIBRATING SCREENS (NOT IN SERVICE)
RETURN SLUDGE
WASTE SLUDGE
SLUDGE HOLDING BASINS
FINAL CLARIFIER
TRAILER INFLUENT
CL_2
CHLORINE CONTACT
TO CREEK
LEGEND:
------ NOT IN SERVICE

PLANT Q

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant Q, a Subcategory V, Knit Fabric Finishing plant. The objectives of this pilot plant were to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant Q, determine the effectiveness of the technologies for meeting the BATEA guideline limitations, and define the mutually (ATMI, EPA and ES) agreed to recommendations for the most cost-effective treatment process.

The existing wastewater treatment facilities at Plant Q consists of secondary biological treatment followed by multi-media filtration (tertiary treatment). The filtration system was required because the plant discharges into a water quality limited stream. The experimental testing was performed with the secondary clarifier effluent prior to chlorination instead of the final discharge from the tertiary portion of the system.

The information generated during this study and presented in this report provides the basis for the following conclusions and recommendations.

CONCLUSIONS

1. The existing secondary biological treatment facilities at Plant Q are effectively treating the textile plant wastewater and achieving the Best Practical Technology (BPT) effluent guideline limitation values for all Subcategory V parameters.
2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent guideline limitations additional treatment facilities beyond the BPT (secondary treatment) plant are required to remove BOD_5, COD and TSS.
3. The following observations and conclusions were made from the pilot plant screening experiments at Plant Q:
   a. Coagulation/Clarification and Multi-Media Filtration (Mode A) - The optimum coagulating conditions were determined by jar tests to be pH 6.5 to 7.0 with a coagulant dosage of 20 mg/l alum (as Al^{+3}) plus 0.75 mg/l anionic polymer (American Cyanamid 837A). The reactor/clarifier removed BOD_5, COD, TSS, color

and chromium. The performance of the reactor/clarifier deteriorated at loadings in excess of 400 gpd/ft^2. The multi-media filter further removed COD and TSS. The optimum loading for the multi-media filter was 3 gpm/ft^2.

b. Multi-Media Filtration Followed by Granular Carbon Adsorption (Mode B) - The multi-media filter removed BOD_5, COD, TSS and color. The optimum surface loading rate for the filter was 3 gpm/ft^2. The carbon column further reduced BOD_5, COD, TSS and color in the wastewater as well as removed chromium.

c. Multi-Media Filtration Followed by Ozonation (Mode C) - As discussed under the Mode B experiment, the multi-media filter removed BOD_5, COD and TSS and was most effective at a surface loading rate of 3.0 gpm/ft^2. Ozone batch testing reduced COD and color at an ozone dosage of 1260 mg/l (utilized) basis.

d. Ozonation (Mode D) - Batch ozonation tests of the BPT effluent reduced COD and color.

e. Multi-Media Filtration with Precoagulation (Mode F) - Coagulant dosages for the screening experiment were 10 mg/l alum (as Al^{+3}) which was greater than required. The filter removed BOD_5, COD and TSS, but filter run times were only two to six hours because of the excess coagulant.

f. Dissolved Air Flotation (Mode G) - The dissolved air flotation experiment conducted with batch tests of the BPT effluent were not successful in removing TSS. The BOD_5 and COD remained essentially the same and the TSS increased because of the coagulant addition (20 mg/l alum, as Al^{+3}).

4. The four candidate BATEA processes (those showing the greatest potential for favorable treatment effectiveness) for Plant Q are reactor/clarifier followed by multi-media filter (Mode A), multi-media filter followed by carbon columns (Mode B), multi-media filter followed by ozonation (Mode C) and multi-media filtration with precoagulation (Mode F).

5. Both Mode B (multi-media filtration followed by carbon adsorption) and Mode C (multi-media filtration followed by ozonation) demonstrated the ability to achieve a projected effluent quality that

was within the BATEA guideline values for Plant Q.

6. Comparative capital cost and operating and maintenance cost indicate that Mode B is significantly less expensive than Mode C.

RECOMMENDATIONS

1. Multi-media filtration followed by carbon adsorption (Mode B) is the recommended BATEA process for Plant Q. The projected effluent quality is within the BATEA guideline values.
2. The recommended surface loading for the multi-media filter is 2 gpm/ft^2. The recommended empty bed hydraulic retention time for the carbon columns is 45 minutes. Process design criteria are presented in Chapter VI.

PLANT Q

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the waste treatment plant effluent from the two manufacturing plants that comprise the Plant Q manufacturing facility, a Subcategory V (Knit Fabric Finishing) Plant. One plant is engaged in the manufacture of warp knitted fabrics from various man-made fibers, which are subsequently dyed and finished. The other plant is solely a dyeing and finishing plant for circular knitted fabrics, mostly of 100% texturized polyester knits. The primary fibers used are polyester, polyamide and acetate. The production processing includes scouring, dyeing and special finishes (softeners, antistats, fluorocarbons, flame retardants, melamine-formaldehyde, polyvinyl acetate and methacrylate resins).

PRODUCTION DATA

The BATEA pilot plant was operated during a 48-day period (August 22, 1977 through October 9, 1977) at Plant Q. The finished production during this same 48-day period totaled 6,195,114 pounds of material. The production during the days the plants were operating averaged 157,840 pounds per day (see letter in Appendix E). The two manufacturing plants have a maximum dyeing and finishing capacity of approximately 210,000 pounds per day. Finished materials included 100% polyamide, 100% polyester, 100% acetate, 80% acetate/20% nylon, 95% polyester/5% nylon and 80% triacetate/20% nylon.

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant Q is presented in Figure C-16(Q). More specific process information is summarized in Table C-29(Q).

The raw wastewater from the two manufacturing facilities are combined prior to treatment. The incoming waste is first equalized in an aerated mixing tank before the waste enters the aeration basin. The two aeration basins with a total volume of 3.24 million gallons provides a total detention time of 15.6 hours. Aeration is provided by surface aerators at a power to volume ratio of 148 HP/MG. Following aeration, the bio-solids are separated from the water in two final clarifiers. Sludge is returned to the

TABLE C-29(Q)

PLANT Q

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow - 5.0 MGD; normal flow - 2.5 MGD

Equalization

No. of Basins - 1
Basin Size - 1.65 MG
No. of Aerators - 3
Aeration - 40 hp (each); 73 HP/MG
Detention Time - 8 hours (at design flow)

Neutralization

None

Nutrient Addition

$NaNO_3$

Screening

Bar Screens - 2-in (parallel, vertical)
Fine Screens - 1 1/4-in (diamond)

Aeration Basin

No. of Basins 2
Volume (Total) 3.24 MG
Aeration 480 HP; 148 HP/MG
Detention Time - 15.6 hrs (at design flow)

Secondary Clarifiers

No. of Clarifiers - 2
Size: Diameter - 75 ft
Side Water Depth - 10 ft
Recycle rate - 2.4 MGD (total)

Chlorination Facilities

No. of Basins - 1
Basin Size - .104 MG
Detention Time - 30 min (at design flow)

(continued)

TABLE C-29(Q)

(continued)

Multi-Media Filters

No. of Filters - 4
No. in operation at one time - 3
Application Rate - 3.5 gpm/ft^2 (at design flow)
Length - 30 feet
Diameter - 10 feet
Chemical Feed to Filters Provided
Backwash Water Storage - 69,000 gallons

Sludge Digestion

Flow - 0.130 MGD
No. of Tanks - 1
Tank Volume - 0.925 MGD
Detention Time - 7.1 days

Sludge Concentrator

No. of Basins - 1
Sludge Holding - 5,160 c.f.
Detention Time - 6 hours

Sand Beds

No. of Beds - 9
Total Area - 28,970 ft^2

Post Aeration

Basin Volume - .0875 MG
No. Aerators - 2
Aeration - 5 hp (each); 114 HP/MG
Detention Time - 26 minutes (at design flow)

areation basin or pumped to the aerobic sludge digester. The sludge is then concentrated in the sludge thickener with the supernatant returned to the waste treatment plant influent and the waste sludge is dried in the sand beds. The normal sludge age is approximately 15 to 20 days. The supernant from the secondary clarifiers is chlorinated and pumped through a multi-media filtration unit. A precoagulant and/or powdered activated carbon are injected into the filter influent. The effluent is discharged to the receiving stream after post aeration.

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data of the waste treatment plant, as reported by the plant, are shown in Appendix A for the one-year period immediately prior to and including the period of the pilot study. Daily operating data as reported by the plant are also presented in Appendix A for the period the pilot studies were in progress. The discharge values reported for the last year are compared to the present permit values in Table C-30(Q). The effluent values reported in this table are final effluent numbers. The pilot plant trailer operated on the secondary clarifier effluent which was upstream of the filtration units. The clarifier effluent quality is also presented in Appendix A.

Based on the data presented in Appendix A and in Table C-30(Q), the waste treatment plant is within present NPDES permit values for 30-day averages for all parameters. The daily maximums for TSS and BOD_5 were exceeded once and twice, respectively, during the time period reported.

During the on-site experimental study there were no major effluent quality upsets created by production changes or biological treatment operational problems. Some unusual production and waste treatment plant operation occurrences that influenced the pilot plant operation are noted below:

- September 3, 4 and 5, 1977 - Plant production facilities were shut down for the Labor Day weekend.
- August 28, September, 11 & 18, October 2 & 6, 1977 - Plant production facilities were shut down for the weekend.
- October 4, 1977 - Repair and start-up of an aerator in the aeration basin created re-suspension of some settled mixed liquor solids, resulting in a high concentration of TSS in the secondary clarifier discharge.

TABLE C-30(Q)

PLANT Q

COMPARISON OF ACTUAL PERFORMANCE WITH BPT GUIDELINE VALUES

Parameter	BPT Guideline Values				Actual Operation (3) Oct. '76 - Sept. '77	
	lbs/day (1)		mg/1 at 2.2 MGD (2)		mg/1	
	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.	Avg.	Max.
BOD_5	378	789	21	43	12	20
COD	4740	9480	258	517	307	447
TSS	1722	3444	94	188	55	165
Phenol	7.9	15.8	0.43	0.86	N.M.	N.M.
Chromium	7.9	15.8	0.43	0.86	N.M.	N.M.
Sulfide	15.8	31.6	0.86	1.72	N.M.	N.M.
Color	N.A.	N.A.	N.A.	N.A.	N.M.	N.M.
Flow	N.A.	N.A.	N.A.	N.A.	2.2	2.5
pH	(6.0 - 9.0)		(6.0 - 9.0)		(6.3 - 7.5)	

(1) See Appendix E for the calculations of the BPT Guideline values.

(2) The average flow for the period October 1976 to September 1977 was reported by the plant as 2.2 MGD.

(3) Effluent from secondary clarifiers not final treatment plant effluent.

N.M. - Not Monitored.

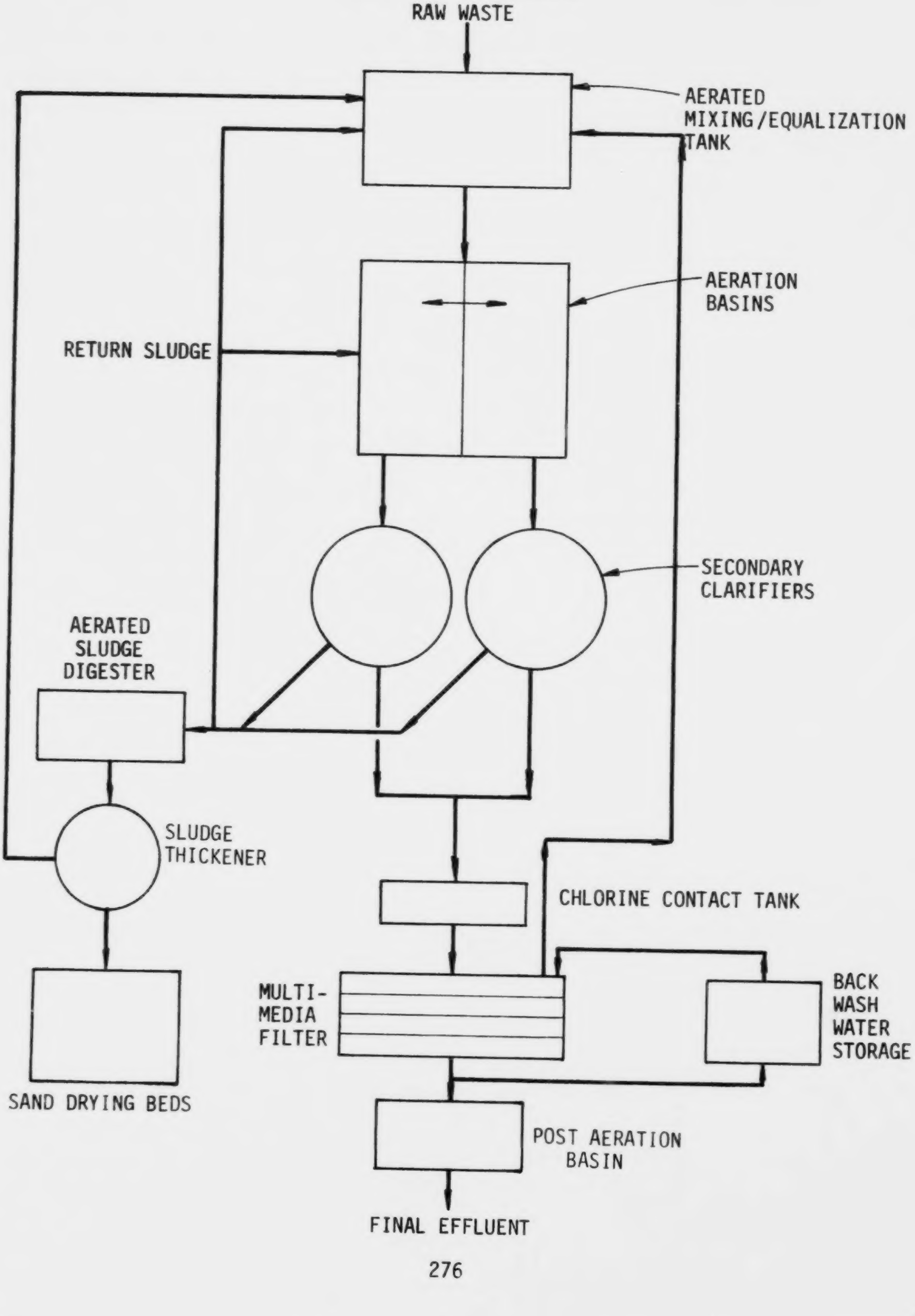
N.A. - Not Applicable

WATER USAGE

Based on an average wastewater flow of 2.46 MGD during the on-site study, 15.6 gallons of wastewater was generated per pound of finished material produced.

FIGURE C-16(Q)

SCHEMATIC FLOW DIAGRAM-EXISTING WASTEWATER TREATMENT FACILITIES AT PLANT Q


RAW WASTE
AERATED MIXING/EQUALIZATION TANK
AERATION BASINS
RETURN SLUDGE
SECONDARY CLARIFIERS
AERATED SLUDGE DIGESTER
SLUDGE THICKENER
CHLORINE CONTACT TANK
MULTI-MEDIA FILTER
BACK WASH WATER STORAGE
SAND DRYING BEDS
POST AERATION BASIN
FINAL EFFLUENT

PLANT E

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant E, a Subcategory V, Knit Fabric Finishing Plant. The objectives of this pilot plant study are to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant E, determine the effectiveness of the technologies for achieving the BATEA guideline limitations and define the mutually (ATMI, EPA and ES) agreed upon recommendations for the most cost-effective treatment process(es).

Existing wastewater treatment facilities at Plant E include screens, aeration, secondary clarification, chlorination and sludge lagoons. The experimental testing was performed on the secondary clarifier effluent.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations.

CONCLUSIONS

1. The existing wastewater facilities at Plant E were achieving the Best Practical Technology (BPT) guideline effluent limitations for all parameters during the period the pilot plant study was conducted.
2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations additional treatment beyong BPT is required to reduce TSS, BOD_5 and COD.
3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant E.
   a. Coagulation/clarification followed by Multi-Media Filtration (Mode A) - A variety of metallic coagulants and combinations of coagulants as well as cationic polymers were jar tested for effectiveness of transmittance improvement, turbidity reduction and minimal sludge production. American Cyanamid 572-C at 20 mg/l dosage was determined to be the most overall effective coagulant. This dosage was utilized with the reactor clarifier at various overflow rates and the optimum

chosen as 400 gpd/ft^2. The clarifier removed BOD_5, TSS, color and TOC. Additional removals were obtained by the multi-media filter an an optimum loading rate of 5.0 gpm/ft^2. Overall, Mode A achieved 77% BOD_5 removal (effluent 3 mg/l), 59% COD removal (effluent 92 mg/l), and 92% TSS removal (effluent 4 mg/l) at the optimum loading rates during screening.

b. Multi-Media Filtration Followed by Activated Carbon Adsorption (Mode B) - The multi-media filter reduced the TSS level by 80% and COD by 7% at the optimum loading rate of 3.0 gpm/ft^2. Utilizing Westvaco WV-1 granular activated carbon at a hydraulic residence time of 45 minutes in the carbon columns following filtration, 88% additional COD was removed. Overall BOD_5 removed was 78%.

c. Multi-Media Filtration followed by Ozonation (Mode COD) - Mode C batch experiments were conducted while the multi-media filter was being loaded at 3 gpm/ft^2. Ozone dosage of 32 to 737 mg O_3 utilized/l or 0.27 to 6.25 lb O_3 utilized/lb COD were applied to filter effluent. Maximum COD reduction was 40% (118 to 71 mg/l) at 737 mg O_3 utilized/l. Color removal was maximized at approximately 50 mg O_3 utilized/l. BOD_5 was consistently increased as a result of ozonation. Increases from 11 mg BOD_5/l (filter effluent) to as high as 89 mg BOD_5/l (after ozonation) were noted.

d. Multi-Media Filtration With Pre-Coagulation (Mode F) - Hercofloc 855 cationic polymer was utilized as a pre-filter aid at 0.75 mg/l dosage. Excellent TSS removal of 88% was obtained at the optimum filter loading rate of 3 gpm/ft^2, but only 29% COD reduction was achieved.

e. Dissolved Air Flotation (Mode G) - Bench-scale dissolved air flotation experiments were performed at 100%, 50% and 33% recycle using 20 mg/l American Cyanamid 572-C as a coagulant. At 100% recycle, 44% COD and 59% TSS were removed.

4. The candidate process technologies showing the greatest potential for favorable treatment effectiveness for Plant E were coagulation/clarification followed by multi-media filtration (Mode A) and multi-media filtration followed by granular carbon adsorption (Mode B).

5. Mode B achieved all BATEA guideline values for Plant E. However, Mode A also achieved all BATEA guideline values except COD which exceeded the BATEA guideline by 18 mg/l.

RECOMMENDATIONS

1. Multi-media filtration followed by granular carbon adsorption is the recommended BATEA process for Plant E. The projected effluent quality for this process will achieve all BATEA guideline values.

2. The recommended multi-media filter surface loading rate is 3 gpm/ft^2. The carbon column hydraulic residence time should be 45 minutes. The carbon capacity loading is 0.35 lb soluble COD/lb carbon. Process design criteria are presented in Chapter VI. This process design criteria is based on treatment of the entire BPT effluent stream with multi-media filter and carbon columns. However, if the entire BPT effluent stream was treated by multi-media filtration and then split such that only 50% was treated by granular carbon adsorption, then the combined effluent could still meet all BATEA guideline parameters. Using this method of treatment substantial installation and operation savings could be incurred.

PLANT E

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the waste treatment plant effluent from the Plant E manufacturing facility, a Subcategory V Plant (Knit Fabric Finishing). The facility consists of conventional scouring and dyeing only employing nylon as the primary fiber.

PRODUCTION DATA

The BATEA pilot plant was at the Plant E site for a 52-day period (March 30, 1978 through May 22, 1978). Due to the Plant E shutdown, the pilot plant did not operate from March 31 through April 9, 1978, nor from April 29 through May 7, 1978 and on weekends. During the days, Plant E was operating production averaged 56,274 pounds/day. The finishing plant has a maximum processing capacity of approximately 86,000 lbs/day (See Appendix E).

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant E is presented in Figure C-17(E). More specific process information is summarized in Table C-31(E).

The incoming waste is primarily industrial combined with approximately 1% sanitary waste. Raw wastewater from the finishing plant is first passed through two-inch bar screens and a Parshall flume into an aeration basin with a volume of 3.0 MG and a design detention time of 84 hours. There are eight surface aerators providing a total of 240 horsepower with a power to volume ratio of 80 HP/MG. Following aeration, the bio-solids are separated in a 54-foot diameter clarifier with a 10-foot side water depth. The recycle rate from the clarifier is designed for up to one million gallons per day. Sludge can be recycled to the aeration basin or wasted to a sludge lagoon. The clarified effluent is chlorinated prior to discharge into the receiving stream.

TABLE C-31(E)

PLANT E

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow - 1 MGD (1% sanitary waste)

Actual Flow - 0.715 MGD during Pilot Plant Operations
0.679 MGD average during previous 12 month period

Equalization

None

Neutralization

None

Nutrient Addition

None

Screening

Bar Screens - 2 inch

Aeration Basin

Basin Size - 3.0 MG

Aeration (Total) = 240 HP (surface aerators); 80 HP/MG

Detention Time - 72 hours at design flow
34 hours during Pilot Plant Operations
106 hours for previous 12 month period

Secondary Clarifier

Size: Diameter - 54 ft.
Side water depth - 10 ft.
Recycle rate - 1.0 MGD maximum

Other Operations/Facilities

Chlorination

Sludge Lagoon

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The waste treatment plant reported monthly operating data for the one-year period immediately prior to and including the period of the pilot study. These are shown in Appendix A. Daily operating data, as reported by the plant, are also presented in Appendix A for the period the pilot studies were in progress. Table C-32(E) is a comparison of the discharge values reported for the last year with the BPT guideline values. The pilot plant trailer operated with the secondary clarifier effluent prior to chlorination.

Based on the data presented in Appendix A and in Table C-32(E), the waste treatment plant obtained an overall BOD_5 removal efficiency of 97%. However, BOD_5, COD and TSS BPT guidelines were exceeded at various times during 1977-1978. An important factor to consider is that the effluent averages are based on a minimal number of composite samples as indicated by Appendix A data.

During the on-site experimental study, there were several production and waste treatment plant operational problems which caused variations in BPT effluent quality. Some of the unusual production and waste treatment plant operational occurrences which influenced the pilot plant operation are summarized below:

Date	Description of Problem	Effect on Pilot Plant Operation
April 1-9, 1978	Plant production shutdown delayed start-up of experimental program. BPT waste characteristics would not have been representative of normal BPT operation during the critical screening phase of the pilot plant program.	Delayed pilot plant screening program.
March 28-May 22, 1978	4-6 inches of floating scum and sludge covering quiescent portions of the aeration basin during the study.	Not characteristic of a well operating BPT system.

TABLE C-32(E)

PLANT E

COMPARISON OF ACTUAL PERFORMANCE TO BPT GUIDELINE VALUES

Parameter	BPT Guideline Values				Actual Operation (4) April '77 - March '78	
	lbs/day (1)		mg/l at 0.679 MGD (2)		mg/l	
	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.	30-Day Avg. (3)	Max. (3)
BOD_5	140.7	281.4	25	50	7 - 81(6)	74 - 133 (3)
COD	1688.2	3376.5	298	596	81 - 510(3)	235 - 560
TSS	613.4	1226.8	108	217	<1 - 128(1)	7 - 130
Oil & Grease	-	-	-	-	-	-
Phenol	2.81	5.63	0.50	0.99	<.05 - 0.1(0)	0.1
Chromium	2.81	5.63	0.50	0.99	<.002 - .02(0)	n.m.
Sulfide	5.63	11.25	0.99	1.99	<0.05	n.m.
Flow, (MGD)	n.a.	n.a.	n.a.	n.a.	0.613 - 0.773	0.710 - 0.911
pH	Within 6.0 - 9.0				7.0 - 7.9(0)	8.0 - 8.2

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(1) See Appendix E for the calculations of the BPT Guideline Values.

(2) Average flow for the period of April '77 through March '78 as reported by the plant.

(3) The figures in parentheses represent the number of months reported in the 12 month period in which the plant monthly averages of maximum days exceed the BPT guidelines.

(4) These figures represent the range of daily maximum values for the 12 month period as reported by the plant.

n.a. not applicable

n.m. not measured

Date	Description of Problem	Effect on Pilot Plant Operation
March 31-April 9, 1978	Plant production shutdown for dyeing and finishing.	Delayed pilot plant candidate mode program.
May 16, 1978 and May 19, 1978	Floating sludge in final clarifier caused by scum removal mechanism failure. Floating scum and sludge from aeration basin covered the entire clarifier surface.	Overloaded the pilot plant equipment with abnormal TSS concentrations. Data not representative of normal operation.

Also, during the pilot plant program the aerators were cycled on and off such that four operated continuously, but in different sections of the aeration basin. Effluent D.O. concentrations prior to cycling were 5 to 7.0 mg/l. By cycling power was conserved and sufficient D.O. was maintained in the effluent. However, the plant should be careful to maintain sufficient D.O. within all sections of the basin.

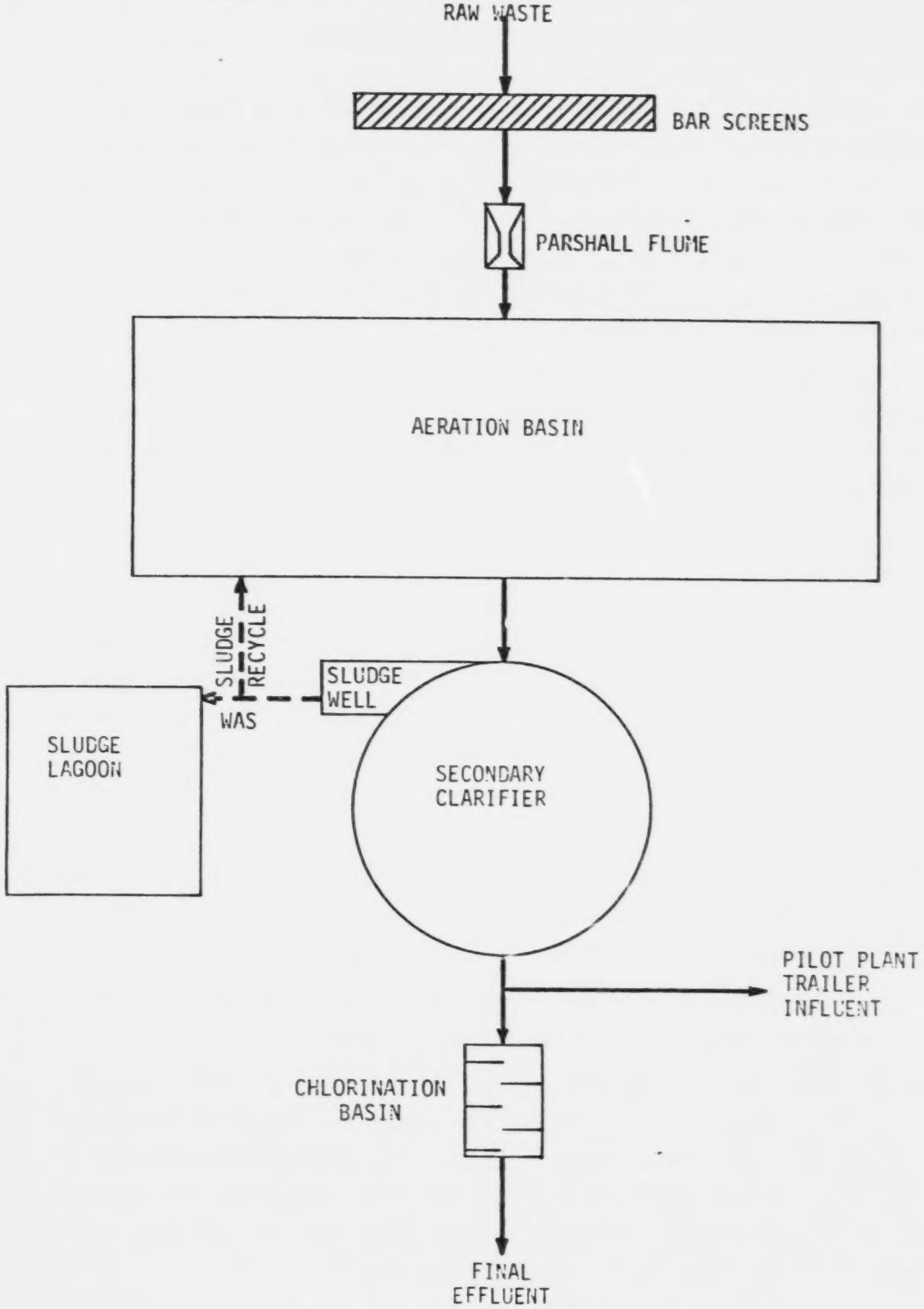
WATER USAGE

Based on an average wastewater flow of 0.714 MGD during the on-site study, 12.7 gallons of wastewater were generated per pound of finished material produced.

FIGURE C-17(E)

SCHEMATIC FLOW DIAGRAM

EXISTING WASTE TREATMENT FACILITIES AT PLANT E


RAW WASTE
BAR SCREENS
PARSHALL FLUME
AERATION BASIN
SLUDGE RECYCLE
SLUDGE WELL
WAS
SLUDGE LAGOON
SECONDARY CLARIFIER
PILOT PLANT TRAILER INFLUENT
CHLORINATION BASIN
FINAL EFFLUENT

PLANT F

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant F, a Subcategory VI (Carpet Mills) Plant. The objectives of this pilot plant study are to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant F, determine the effectiveness of the technologies for achieving the BATEA guideline limitations and define the mutually (ATMI, EPA and ES) agreed upon recommendations for the most cost-effective treatment process(es).

Existing wastewater treatment facilities at Plant F include latex settling ponds, manually and mechanically cleaned bar screens, an equalization basin, an aeration basin, a secondary clarifier, chlorination, a finishing pond and sludge drying lagoons.

CONCLUSIONS

1. The existing wastewater facilities at Plant F were achieving the Best Practicable Technology (BPT) guideline effluent limitations during the period the pilot plant study was conducted based on in-plant data. Based on trailer influent samples taken prior to the existing polishing pond and analyzed by the study support laboratory the secondary treatment facility was meeting all BPT limitations except sulfide.
2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations additional treatment beyond BPT is required to reduce COD, TSS, sulfide and color.
3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant F.
    a. Coagulation/Clarification Followed by Multi-Media Filtration (Mode A) - The optimum coagulant combination tested for use with the reactor/clarifier was American Cyanamid 572C at 35 mg/l plus American Cyanamid 836A at 1 mg/l. The reactor/clarifier effectively reduced BOD_5, COD, TSS, phenol, sulfide and color at all loading rates tested.

The most effective performance was achieved at an overflow rate of 400 gpd/ft^2. The multi-media filter provided additional removal of COD, TSS and sulfide at a surface loading of 5.0 gpm/ft^2.

b. Multi-Media Filtration Followed by Activated Carbon Adsorption (Mode B) - The multi-media filter removed BOD_5, COD, TOC, TSS, phenol, chromium and color, with best results achieved at a surface loading rate of 2.0 gpm/ft^2. The carbon columns were operated at 45 minutes hydraulic retention time (HRT) and further reduced the levels of COD, TOC, TSS, phenol and color. Total Mode B reductions included 78 percent BOD_5, 70 percent COD and 56 percent TSS at the most effective loading rate. An increase in % transmittance of 36% was observed at this loading rate.

c. Multi-Media Filtration Followed by Ozonation (Mode C) - The ozone batch tests were conducted with effluent from the multi-media filter at a surface loading rate of 2.0 gpm/ft^2. Ozone dosages were from 0 to 0.53 lb ozone utilized per lb COD with the ozone utilization ranging from 6 to 206 mg/l. The COD level was reduced by approximately 20 percent although reduction was not significantly affected by the dosage.

d. Multi-Media Filtration with Precoagulation (Mode F) - The multi-media filter was operated at surface loading rates of 3.0 to 4.0 gpm/ft^2 with ferric chloride addition at 15 and 35 mg/l as Fe^{+3}. Minimal COD reduction and no TSS reduction was observed under these operating conditions. No improvement in performance over multi-media filtration without precoagulation was evident.

e. Dissolved Air Flotation (Mode G) - Initially three bench-scale dissolved air flotation (DAF) experiments were conducted at 33.3, 50 and 100 percent recycle rates. The results from these initial tests indicated that Mode G was ineffective in treating the Plant F secondary effluent. Additional DAF batch tests at the same recycle rates showed results comparable to coagulation/clarification results. At 33.3 percent recycle, removals of 78 percent COD and 57 percent TSS were achieved.

4. The three candidate BATEA process technologies for Plant F showing the greatest potential for favorable treatment effectiveness are Mode L, coagulation/clarification (with polymer addition), Mode A, coagulation/clarification (with polymer addition) followed by multi-media filtration and Mode H, reactor/clarifier (with polymer addition) followed by multi-media filtration followed by activated carbon contact.

5. Of the three candidate process technologies tested, Mode L was not able to meet the BATEA TSS or color guidelines, but met those for BOD_5, COD and phenol. Modes H and A met BATEA limits for BOD_5, COD, TSS, Phenol and Color. None of the candidate modes tested were able to meet the BATEA sulfide guideline based on support laboratory analytical results. During the candidate mode there was an unusual rise in the BPT effluent sulfides level and subsequent high values of sulfides occurred in the candidate modes. These levels of sulfides had not been experienced during the screening period, nor were they noted by the plant in the historical data. It is not possible, at this time, to determine if these increased sulfide values were accurate or a result of analytical error and/or interference. Because BATEA technologies are not designed to reduce significant levels of sulfides, the Plant F BATEA process selection was not affected by the sulfide excursions.

RECOMMENDATIONS

1. Coagulation/clarification followed by multi-media filtration is the recommended BATEA process for Plant F. The projected effluent quality for this process will achieve all BATEA guideline values except the guideline value for sulfide.

2. The recommended clarifier overflow rate is 400 gpd/ft^2 with addition of 35 mg/l cationic polymer (American Cyanamid 572C) and 1 mg/l anionic polymer (American Cyanamid 836A). The multi-media filter surface loading rate should be 5 gpm/ft^2. Process design criteria are presented in Chapter VI.

PLANT F

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the waste treatment plant effluent from the Plant F manufacturing facility, a Subcategory VI (Carpet Mills) Plant. The plant is engaged in manufacturing carpet from various man-made fibers. The primary fibers used are polyester and nylon. The production processing includes tufting (batch and continuous), dyeing, printing and applying jute backing with latex adhesives to the carpet.

PRODUCTION DATA

The BATEA pilot plant was operated during a 42-day period (April 27, 1978 through June 7, 1978) at Plant F. The finished production during this same 42-day period totaled 11,216,702 pounds of material. The production during the 34 days the plant was operating averaged 329,903 lbs/day (see letter in Appendix E). The daily plant capacity was reported as 460,000 pounds (without secondary backing). No unusual manufacturing occurrences were reported by the plant during the pilot plant operations.

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant F is presented in Figure C-18(F). More specific process information is summarized in Table C-33(F).

The raw wastewater from the latex process is pretreated in five settling ponds and then combined with dyehouse wastewater prior to secondary treatment. The incoming waste passes through a 1-1/2" manually cleaned bar screen, then through a Dalton mechanical screen prior to entering the equalization basin. The process waste is then combined with sanitary waste, which comprises 1% of the total wastewater flow, in the equalization basin before entering the aeration basin. The aeration basin, with a total volume of 10 million gallons, provides a total detention time of 192 hours at design flow. Aeration is provided by 8, 50 HP floating surface aerators at a power to volume ratio of 40 HP/MG.

TABLE C-33(F)

PLANT F

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow = 1.25 MGD

Normal Flow = 1.43 MGD

Flow during Pilot Plant Experiments = 1.50 MGD

Equalization

No. of Basins - 1

Neutralization

Caustic

Nutrient Addition

None

Screening

Bar Screens - 1-1/2" O.C.

Mechanical Screens

Aeration Basin

No. of Basins - 1

Volume (Total) - 10 MG

Aeration - 400 HP; 40 HP/MG

Detention Time - 192 hrs (at design flow)
168 hrs (at normal flow)
160 hrs (during pilot experimentation)

Secondary Clarifiers

No. of Clarifiers - 1

Size; Diameter - 85 ft.

Side Water Depth - 10 ft.

Recycle rate - 1.25 MGD (total)

Chlorination Facilities

No. of Basins - 1

Polishing Pond

No. of Ponds - 1

Pond Size - 18 MG

Following aeration, the bio-solids are separated from the water in an 85 ft. diameter final clarifier. Sludge is returned to the aeration basin or pumped to sludge drying lagoons. Sludge age ranges from 31 to 45 days. The supernatant from the secondary clarifier is chlorinated and then flows by gravity into an 18 MG finishing pond prior to being discharged to the receiving stream. Pilot plant experimentation was done on effluent from the secondary clarifier prior to chlorination.

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data of the waste treatment plant, as reported by the plant, are shown in Appendix A for the one-year period immediately prior to and including the period of the pilot study. Daily operating data as reported by the plant are also presented in Appendix A for the period the pilot studies were in progress. The discharge values reported for the last year are compared to the BPT guideline values in Table C-34(F). The effluent values reported in this table are final finishing pond effluent values. The pilot plant trailer operated on the secondary clarifier effluent prior to chlorination and the finishing pond. The only secondary clarifier effluent data available is the data obtained while the pilot plant was on-site.

Based on the data presented in Appendix A and in Table C-34(F), the waste treatment plant including the finishing pond is within present BPT guideline values for 30-day averages for all parameters. Maximum day values were within BPT limits except for one pH excursion.

During the on-site experimental study there were no major effluent quality upsets created by production changes or biological treatment operational problems. Some unusual production and waste treatment plant operation occurrences that influenced the pilot plant operation are noted below:

- April 27 - Two aerators (25%) out of service.
- May 2, 11 - Power failure during the night resulting in aeration basin dissolved oxygen level of <1 mg/l
- May 15 - Broken cable on floating aerator resulted in shutting off all aerators for several hours to repair cable

TABLE C-34(F)

PLANT F

COMPARISON OF ACTUAL PERFORMANCE WITH BPT GUIDELINE VALUES

Parameter	BPT Guideline Values				Actual Operation[3] April '77-March '78		
	lbs/day [1]		mg/l at 1.42 MGD[2]		mg/l		
	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.	30-Day Avg.	(3)	Max.* (3)
BOD_5	1,287	2,573	109	217	24-79	(0)	38-105 (0)
COD	11,580	23,159	978	1,956	250-589	(0)	334-785 (0)
TSS	1,814	3,629	153	306	28-86	(0)	41-203 (0)
Phenol	6.60	13.20	0.56	1.11	0.050-0.125	(0)	0.050-0.125 (0)
Chromium	6.60	13.20	0.56	1.11	<0.02-0.05	(0)	0.02-0.05 (0)
Sulfide	13.20	26.39	1.11	2.23	<0.05-0.11	(0)	0.05-0.30 (0)
Color	N.A.	N.A.	N.A.	N.A.	N.M.		N.M.
Flow	N.A.	N.A.	N.A.	N.A.	1.21-1.57		2.52
pH	(6.0 - 9.0)		(6.0 - 9.0)		6.6-7.4	(0)	6.9-11.0 (1)

---

(1) See Appendix E for the calculations of the BPT Guideline values.

(2) Average flow for the period April '77 through March '78 was reported by the plant at 1.42 MGD.

(3) The figures in parentheses represent the number of months in the 12-month period in which the plant exceeds the BPT guidelines. Actual operation numbers are data taken following the final finishing pond, not secondary clarifier effluent data.

N.M.- Not Monitored.

N.A.- Not Applicable

* These figures represent the range of the monthly maximum values as reported by the plant.

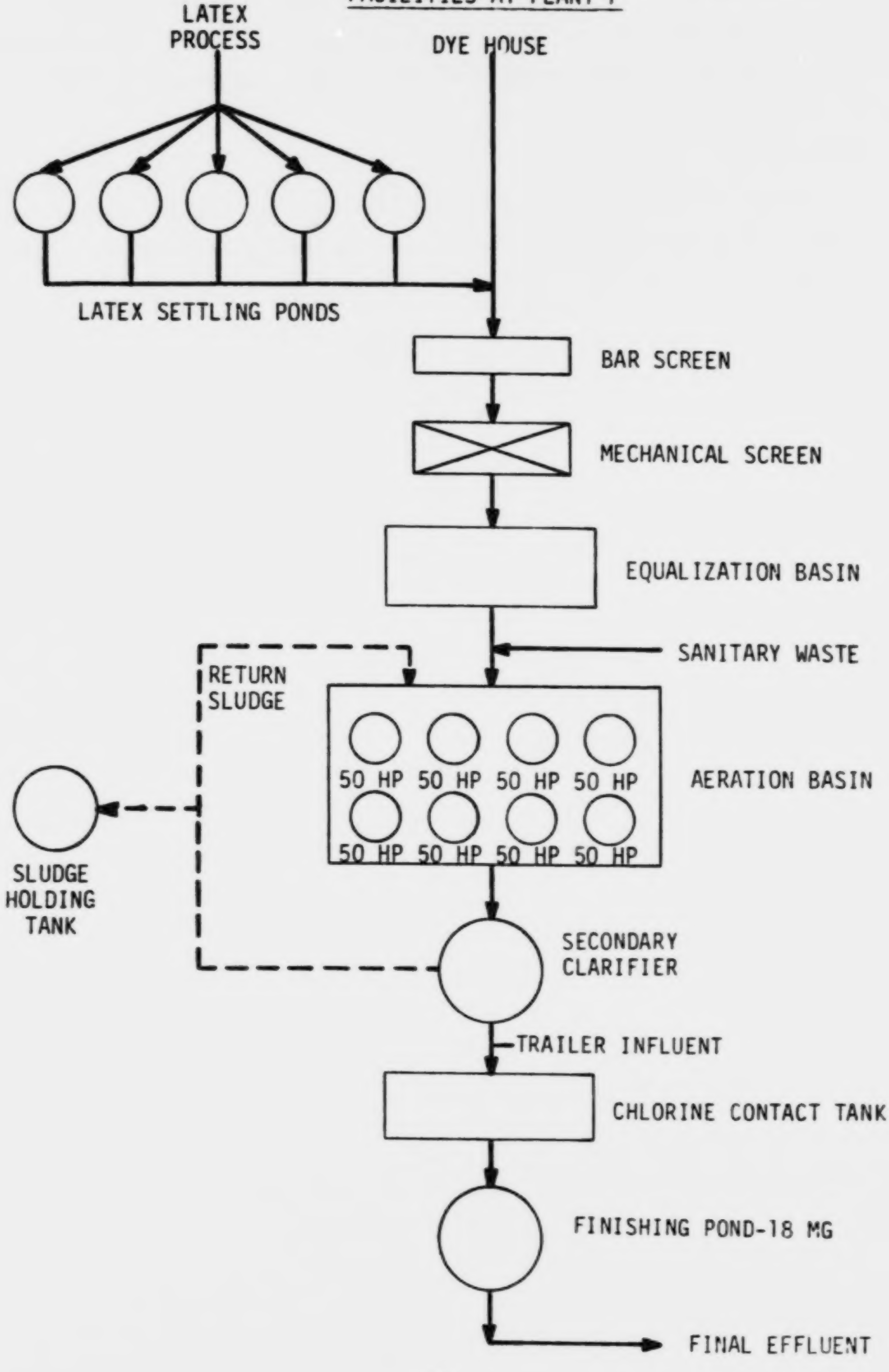
- May 20, June 6 - Heavy lint in secondary clarifier effluent resulted in blocked flow totalizers in pilot plant.
- The plant production facilities were generally in operation Monday through Friday and shut down on weekends.

WATER USAGE

Based on an average wastewater flow of 1.42 MGD during the on-site study, 4.3 gallons of wastewater were generated per pound of material produced.

FIGURE C-18(F)

SCHEMATIC FLOW DIAGRAM-EXISTING WASTEWATER TREATMENT FACILITIES AT PLANT F


LATEX PROCESS
DYE HOUSE
LATEX SETTLING PONDS
BAR SCREEN
MECHANICAL SCREEN
EQUALIZATION BASIN
SANITARY WASTE
RETURN SLUDGE
50 HP
50 HP
50 HP
50 HP
50 HP
50 HP
50 HP
50 HP
AERATION BASIN
SLUDGE HOLDING TANK
SECONDARY CLARIFIER
TRAILER INFLUENT
CHLORINE CONTACT TANK
FINISHING POND-18 MG
FINAL EFFLUENT

PLANT S

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant S, a Subcategory G (VII) Stock and Yarn Dyeing and Finishing Plant. The objectives of this study are to evaluate the potential BATEA technologies for treating the BPT effluent of Plant S, determine the effectiveness of the technologies for meeting the proposed BATEA effluent limitations, and define the mutually (ATMI, EPA and ES) agreed upon recommendation for the most cost-effective treatment process(es).

Existing wastewater treatment facilities at Plant S include equalization, aeration, secondary clarification, polishing pond, chlorination and post aeration. The experimental testing was performed on the secondary clarifier effluent prior to the final polishing pond and chlorination.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations:

CONCLUSIONS

1. The existing secondary clarifier effluent quality did not achieve the Best Practicable Technology (BPT) guideline limitations for BOD_5 during the period the pilot plant study was conducted. However, effluent from the final polishing pond did meet the BPT guideline values.
2. To achieve the Best Available Technology Economically Achievable (BATEA) effluent limitations additional treatment beyond BPT (following secondary clarification) is required to reduce the BOD_5, COD and TSS.
3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant S:
   a. Coagulation/Clarification Followed by Multi-Media Filtration (Mode A) - Jar tests were conducted in which American Cyanamid 573-C and 581-C were selected as the most effective coagulants tested. Jar test results indicated 20 ppm as the

optimum dosage. However, during screening operation cationic polymer was added at dosages of 24 to 45 ppm. The reactor clarifier was operated at overflow rates of 170 to 800 gpd/ft^2. At reactor clarifier overflow rates of 400-600 gpd/ft^2 and multimedia filter surface loading rates of 3 to 5 gpm/ft^2 removals of 89-96 percent BOD$_5$, 54-84 percent COD and 60-73 percent TSS were achieved. Typical Mode A effluent quality at 400 gpd/ft^2 overflow rate and 40 ppm cationic polymer dosage was 2 mg/l BOD$_5$, 37 mg/l COD and 8 mg/l TSS. Sulfides, phenol and chromium were all below detectable limits for the BPT effluent.

b. Multi-Media Filtration Followed by Granular Carbon Adsorption (Mode B) - At multi-media filter surface loading rates of 4 to 6 gpm/ft^2 14 to 36 percent COD, 44-55 percent TSS, and 67-83 percent BOD$_5$ were removed. Utilizing Westvaco WV-L granular carbon at an empty bed retention time of 45 minutes following multimedia filtration only 5 to 33 percent COD and 27 percent BOD$_5$ was additionally removed by the carbon columns. Typical Mode B effluent quality was 5 mg/l BOD$_5$, 42 mg/l COD, 9 mg/l TSS, and 3 mg/l TOC. Breakthrough data indicates desorption of soluble COD occurred for 20 percent of the data points.

c. Multi-Media Filtration Followed by Ozonation (Mode C) - During the Mode C Batch experiment the multi-media filter was being operated at a loading rate of 6 gpm/ft^2. Filter effluent containing 6 mg/l TSS was ozonated in a batch reactor. Ozonation was very effective for color removal (61 percent) at the low dosages of 30-60 mg/l ozone utilized. Only 36 percent COD and 22 percent BOD$_5$ was removed at 160 mg/l O_3 dosage. However, at 245 mg/l O_3 dosage 87 percent COD removal was achieved.

d. Ozonation (Mode D) - Ozonation of the "BPT" effluent was effective for color recuction at fairly low ozone utilized dosages. However no COD removal was observed after 245 mg/l O_3 utilized. Dosages in excess of 465 mg/l O_3 utilized were required to obtain 41 percent COD reduction. At 465 mg/l O_3 dosage 78 percent BOD$_5$, 24 percent TSS and 77 percent of the color was removed. Mode D effluent quality at 465 mg/l O_3 utilized was 5 mg/l BOD$_5$, 65 mg/l COD, and 54 mg/l TSS.

e. Multi-Media Filtration with Pre-filter Coagulation (Mode F) - Pre-filter coagulation of the multi-media filter influent with 11-13 mg/l cationic polymer provided no improvement in performance for TSS, COD, BOD or color reduction compared to multi-media filter operation without pre-coagulation. Loading rates in the of 2.5 to 4.5 gpm/ft^2 were evaluated. 36-57 percent TSS, 57-84 percent BOD and 0-51 percent COD was removed. However, filter run times were 4 hours or less compared to Mode B (no pre-filter coagulation) filter run times of 12 hours or more.

f. Dissolved Air Flotation (Mode G) - Dissolved air flotation (DAF) was not effective for suspended solids removal at 100, 50 or 33 percent recycle rates. Because of the low suspended solids in the BPT effluent and the addition of cationic polymer as a coagulant, the DAF effluent suspended solids were greater than the influent suspended solids.

4. The three candidate BATEA processes for Plant S were coagulation/clarification followed by multi-media filtration (Mode A), multi-media filtration followed by granular carbon adsorption (Mode B) and multi-media filtration followed by ozonation (Mode C).

5. Based on data taken during candidate operations Mode A effluent achieved all BATEA guideline limitations except those for COD (by 17 mg/l; 25%) and TSS (by 7 mg/l; 78%). Mode B was capable of treating the BPT effluent to within BATEA limits for all parameters except COD (by 19 mg/l; 28%). Mode C effluent met all BATEA limitations except COD (by 52 mg/l; 75%) and TSS (by 27 mg/l; 300%).

RECOMMENDATIONS

1. Coagulation/clarification followed by multi-media filtration (Mode A) is the recommended BATEA process for plant S. The projected effluent quality from this process did not achieve the BATEA guidelines for COD or TSS. Mode A produced an effluent quality better than the other technologies evaluated in terms of COD . Based on screening data it is believed that reducing the overflow rate of the reactor/clarifier and increasing the coagu-

lation dosage would improve TSS and COD removal performance. If the multi-media filter were operated at a surface loading rate less than 5 gpm/ft^2 and with a finer media then the effluent TSS value may be reduced to the BATEA guideline values of 9 mg/l.

2. The recommended design loading for the reactor/clarifier is 200 gpd/ft^2 with a coagulant dosage of 25-45 mg/l cationic polymer. The filter loading rate should be 2.5 gpm/ft^2.

PLANT S

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the secondary clarifier effluent of the Plant S textile manufacturing facility, a Subcategory VII Plant (Stock and Yarn Dyeing and Finishing). The primary fibers used are cotton, polyester and blends of cotton, polyester and rayon. The production processing includes bleaching, mercerizing and dyeing (Package and Hussong).

PRODUCTION DATA

The BATEA pilot plant was operated for a 38-day period (November 14, 1977 through December 21, 1977) at Plant S. The production during this same 38-day period totaled 1,371,852 pounds of material. The production during the days the plant was operating averaged 50,809 pounds/day (see letter in Appendix E). Finished materials included 100 percent cotton, cotton/polyester blends, cotton/rayon blends and 100 percent polyester. Production capacity for the manufacturing plant is approximately 82,000 pounds per day of stock and yarn.

EXISTING WASTE TREATMENT PLANT DESCRIPTION

A schematic flow diagram of the existing wastewater treatment facilities at Plant S is presented in Figure C-19(S). More specific process information is summarized in Table C-35(S).

The raw wastewater from the manufacturing facility enters a 1.8 million gallon equalization basin which provides a detention of 1.2 days at design flow. Mixing to provide proper equalization in provided by one 30 horsepower floating mechanical surface aerator which corresponds to a power to volume ration of 17 HP/MG. Following equalization the waste enters the 3.9 million gallon aeration basin which provides a detention time of 2.6 days at design flow. Aeration is provided by six 30 horsepower mechanical, floating, surface aerators with a power to volume ratio

TABLE C-35(S)

PLANT S

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow = 1.5 MGD (approximately 3% sanitary waste)
Normal Flow = 1.24 MGD
Flow During Pilot Operations = 1.24 MGD

EQUALIZATION

No. of Basin - 1
Basin Size - 1.8 MG
Mixing - 30 HP (Surface Aerator): 17 HP/MG

NUTRIENT ADDITION

None

ACID ADDITION

None

SCREENING

None

AERATION BASIN

No. of Basins - 1
Basin Size - 3.9 MG
Aeration - 180 HP (Surface Aerators): 46 HP/MG
Detention Time - 62 hours at design flow
75 hours at normal and pilot operation period flow

SECONDARY CLARIFIERS

No. of Clarifiers - 2
Size: Diameter - 50 ft.
Side Water Depth - 10 ft.

(continued)

TABLE C-35(S)
(continued)

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

POLISHING POND

No. of Basins - 1

Basin Size - 3.8 MG

Detention Time - 60 hours at design flow
74 hours at normal and pilot operation period flow

OTHER OPERATIONS

Chlorination

Post Aeration Basin (94,000 gallons, 3 HP) of 46.0 HP/MG. Following aeration, flow is split and the bio-solids are separated from the liquid in the two final clarifiers. Sludge is returned to the aeration basin. The normal sludge age is approximately 80 days. Effluent from the two clarifiers is transferred to a 3.8 million gallon polishing pond with 2.5 days detention time. Following the polishing pond effluent is chlorinated and passed through a 94,000 gallon holding basin prior to discharge to the receiving stream. Pilot plant experimentation was done using the secondary clarifier effluent (prior to the polishing pond).

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data, of the waste treatment plant as reported by the plant, are shown in Appendix A for the one-year period immediately prior to and including the period of the pilot study. Daily operating data, as reported by the plant, are also presented in Appendix A for the period the pilot studies were in progress. The discharge values reported for the last year are compared to the BPT guideline values in Table C-36(S). The effluent values reported in this table are final polishing pond effluent numbers. The pilot plant trailer was operated with the secondary clarifier effluent prior to the polishing pond and chlorination. The only secondary clarifier effluent data available is the data obtained while the pilot plant was on-site.

Based on the data presented in Appendix A and in Table C-36(S), the existing waste treatment plant including the final polishing pond was within BPT guideline values for 30-day averages and daily maximums for BOD_5, COD, TSS and Phenol. Chromium and sulfide values were not reported by the plant.

TREATMENT PLANT INFLUENT VARIABILITY

During the period the pilot plant studies were underway, the textile manufacturing plant generally operated five days per week. This variability is not reflected in the overall statistical treatment of the data in this report since only days when data was available were included. With an aeration basin hydraulic retention time of 62 hours at a flow rate of 1.24 MGD, a suitable biological population may be maintained during the periods of low flow.

TABLE C-36(S)

PLANT S

COMPARISON OF ACTUAL PERFORMANCE TO BPT LIMITATIONS

Parameter	BPT GUIDELINE VALUES				Actual Operation(3) Nov. '76 - Oct. '77	
	lbs/day (1)		mg/l at 1.24 MGD(2)		mg/l	
	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.	Avg.	Max.
BOD_5	173	345.5	17	33	3-9 (0)	4-13 (0)
COD	2149	4298	208	416	93-148 (0)	90-180 (0)
TSS	442	884	43	85	2-12 (0)	3-28 (0)
Phenol	3.0	6.1	0.29	0.59	0.005-0.020 (0)	0.005-0.020 (0)
Chromium	3.0	6.1	0.29	0.59	n.m.	n.m.
Sulfide	6.1	12.2	0.59	1.18	n.m.	n.m.
Color					n.m.	n.m.
Flow, (MGD)	n.a.	n.a.	n.a.	n.a.	1.10-1.33	1.3-1.5
pH (unitless)	(6.0-9.0)	(6.0-9.0)	(6.0-9.0)	(6.0-9.0)	7.8-9.0	

(1) See Appendix E for the calculations of BPT Guideline Values.

(2) The average flow for the period of November, 1976 to October 1977 was reported by the plant as 1.24MGD.

(3) Actual operation numbers are taken following the final finishing pond, not secondary clarifier effluent data. Numbers in parenthesis indicate number of times during the period when BPT limits were exceeded.

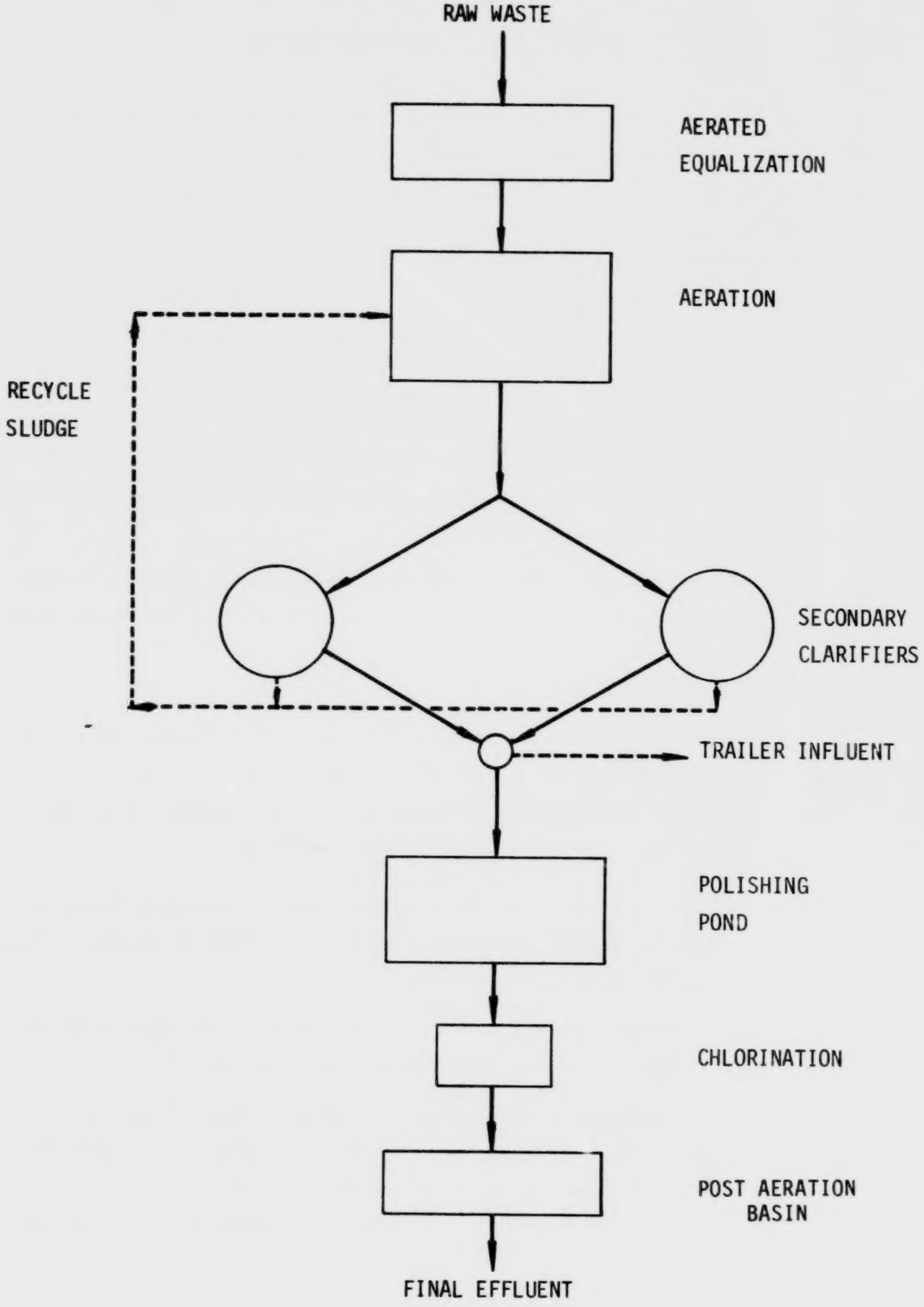
n.m. = not monitored by mill laboratory
n.a. = not applicable

WATER USAGE

Based on an average wastewater flow of 1.24 MGD during the on-site study, 24.4 gallons of wastewater were generated per pound of finished material produced.

FIGURE C-19(S)

SCHEMATIC FLOW DIAGRAM - EXISTING WASTEWATER TREATMENT FACILITIES AT PLANT S


RAW WASTE
AERATED EQUALIZATION
AERATION
RECYCLE SLUDGE
SECONDARY CLARIFIERS
TRAILER INFLUENT
POLISHING POND
CHLORINATION
POST AERATION BASIN
FINAL EFFLUENT

PLANT EE

CONCLUSIONS AND RECOMMENDATIONS

The BATEA pilot plant studies have been completed at Plant EE, a Subcategory IV (Woven Fabric Finishing) and Subcategory VII (Stock and Yarn Dyeing and Finishing) plant. The objectives of this pilot plant study are to evaluate the potential BATEA process technologies for treating the BPT effluent from Plant EE, determine the effectiveness of the technologies for achieving the BATEA guideline limitations and define the mutually (ATMI, EPA and ES) agreed upon recommendations for the most cost-effective treatment process(es).

Existing wastewater treatment facilities at Plant EE include screens, acid and antifoam addition, aeration, secondary clarification, dissolved air flotation and a centrifuge. The experimental testing was performed on the secondary clarifier effluent.

The information generated during this study and presented in this report forms the basis for the following conclusions and recommendations.

CONCLUSIONS

1. The existing wastewater facilities at Plant EE were achieving the Best Practicable Technology (BPT) guideline effluent limitations for all parameters based on average values during the period the pilot plant study was conducted.

2. The BPT plant met all the Best Available Technology Economically Achievable (BATEA) effluent limitations based on average values during the pilot plant sutdy.

3. The following observations and conclusions were made from the pilot-scale screening experiments at Plant EE.

    a. Coagulation/Clarification Followed by Multi-Media Filtration (Mode A) - A variety of metallic coagulants and combinations of coagulants as well as cationic polymers were jar tested for effectiveness of transmittance improvement, turbidity reduction and minimal sludge production. Alum at 30 mg/l (as Al^{+3}) with a pH of 6.5 was determined to be the most overall effective coagulant. This dosage was utilized with the reactor clarifier at various overflow rates and the optimum chosen as 400 gpd/ft^2. COD removal with the reactor clarifier was 11 to 40% while TSS concentrations were increased. However, operation of the multi-media filter at 3.0 to 7.0 gpm/ft^2 removed additional TSS, COD, TOC, sulfide and BOD_5. Overall, Mode A, at 400 gpd/ft^2 and 3 gpm/ft^2, achieved 30% BOD_5, 21% COD, 25% TSS, 28% sulfide and 6% color removal.

b. Multi-Media Filtration Followed by Activated Carbon Adsorption (Mode B) - The multi-media filter did not reduce significant levels of COD, TSS, TOC or sulfide at the various loading rates tested. This was due to low TSS concentration in the BPT effluent (<8 mg/l). Utilizing Westvaco WV-1 at a hydraulic residence time of 45 minutes in the carbon columns following filtration COD reduction (60 to 80%) was obtained. Overall reductions were TSS 50%, sulfide 31%, color 14%, COD 85% and BOD_5 17% at a filter loading rate of 7 gpm/ft^2.

c. Multi-Media Filtration Followed by Ozonation (Mode C) - The Mode C batch tests were conducted with effluent from the multi-media filter at a surface loading rate of 3.0 gpm/ft^2. Effluent TSS was 6 to 7 mg/l and COD ranged from 154 to 187 mg/l. There was an increase in COD across the filter in one of the Mode C experiments. Ozone dosages of 0 to 1005 mg/l ozone utilized were evaluated. BOD_5 consistently increased with ozonation. 35% soluble COD reduction was achieved at a dosage of 41 mg/l O_3 utilized. At this dosage, color reduction was essentially complete. Further significant COD reduction was not achieved until the O_3 utilized dosage was greater than 432 mg/l. Typical Mode C effluent quality at 40 - 50 mg/l O_3 utilized dosage was approximately 90 mg/l COD.

d. Multi-Media Filtration with Precoagulation (Mode F) - Jar tests performed with a variety of coagulants determined 7 to 12 mg/l alum as Al^{+3} at a pH of 6.5 to provide the visual threshold floc formation dosage to use with the multi-media filter. TSS and COD reduction at 3.0 gpm/ft^2 with 7 mg/l alum were slightly better than the Mode B filter at the same rate. Essentially, the same performance level between Mode B and Mode F filter was obtained at 5.0 gpm/ft^2. No TSS reduction was achieved at loading rates of 5.0 and 7.0 gpm/ft^2, but there was 35% COD reduction at 3.0 gpm/ft^2. Due to the observed fluctations in coagulant demand at this site, consistent operation of Mode F is impractical.

e. Dissolved Air Flotation (Mode G) - Bench-scale dissolved air flotation experiments were performed at 100%, 50% and 33% recycle, utilizing 30 mg/l alum at a pH of 6.5 as a coagulant. Neither batch test was effective for TSS removal. Subnatant TSS increased becasue of suspended floc particles. DAF was not as effective as coagulation/clarification.

f. Multi-Media Filtration (Mode I) - Mode I was not screened as a separate treatment technology during the screening period. The data base for Mode I process evaluation was derived from 7 isolated data points during the pilot plant visit at Plant EE when BPT effluent TSS were uncommonly high (30-115 mg/l). The purpose of this was to model filter performance during winter months when, historically, the secondary treatment system at Plant EE has experienced elevated effluent TSS and COD discharges. For the selected group of data, Mode I reduced TSS from 67 to 15 mg/l (78%) and COD from 168 to 104 mg/l (34%).

4. The candidate process technologies showing the greatest potential for favorable treatment effectiveness for Plant EE were coagulation/clarification followed by multi-media filtration (Mode A), multi-media filtration followed by carbon adsoprtion (Mode B), multi-media filtration followed by ozonation (Mode C) and multi-media filtration (Mode I).

5. The four candidate modes achieved all the BATEA effluent guideline values.

6. Based on a cost comparison, multi-media filtration alone (Mode I) is the least expensive technology. All other candidate modes contain multi-media filtration plus another technology.

7. Based on selected data points during the pilot plant study when BPT TSS was significantly above the projected BATEA guideline, multi-media filtration at 7 gpm/ft^2 (Mode I) was able to reduce COD by 34% and TSS by 78% to meet the guideline values.

RECOMMENDATIONS

1. During the pilot plant study period the BPT plant was meeting all BATEA guidelines based on average values. Hence, no further BATEA process technology can be recommended based on overall plant data.

2. For this particular plant site, based on historical operations data and selected pilot plant study period data, a multi-media filter operating at 7 gpm/ft^2 is required to consistently meet projected BATEA guideline values on a year-round basis. If occasional periods of elevated TSS discharge could be controlled through BPT plant operations no filter would be required for year-round compliance with the BATEA limitations.

PLANT EE

INTRODUCTION TO TEXTILE PLANT FACILITIES

INTRODUCTION

The BATEA pilot plant studies were performed on the wastewater treatment effluent from Plant EE. Plant EE is classified as both a Subcategory VII (Stock and Yarn Dyeing and Finishing) and a Subcategory IV (Woven Fabric Finishing) plant. The plant is involved in the bleaching of raw cotton and gauze fabrics. The primary materials involved are 100% cotton and a 70/30 cotton rayon blend.

PRODUCTION DATA

The BATEA pilot plant was operated for a 32 day period (May 30, 1978 through June 30, 1978) at Plant EE. Total production during this period (based on 28 days of Stock and Yarn production and 20 days of Woven Fabric Finishing production) was 2,353,324 lbs. Average daily production for Stock & Yarn Dyeing and Finishing was 56,833 lbs/day; average daily production of Woven Fabric Finishing was 38,100 lbs/day. (See Appendix E.)

EXISTING WASTEWATER TREATMENT PLANT DESCRIPTION

Figure C-20(EE) is a schematic flow diagram of the existing wastewater treatment facility at Plant EE. Table C-37(EE) summarizes more specific process information. The wastewater treatment plant treats all of the waste from Plant EE operations which includes approximately 2% domestic waste.

The wastewater is passed through screens which remove fiber and other solid materials. Before the flow passes into the aeration basin, acid is added for neutralization and antifoam is added for foam control. The aeration basin has a volume of 3 MG and is aerated by eight variable speed surface aerators. Flow from the aeration chamber passes into two parallel secondary clarifiers. Here biological solids are settled and a portion are returned to the aeration basin. A fraction of the biological solids are thickened and wasted. Further thickening of the wasted solids is accomplished by dissolved air flotation followed by a centrifuge unit. Thickened waste solids are then hauled away to land disposal. Supernatant from the secondary clarifiers is treated with antifoam and discharged.

TABLE C-37(EE)

PLANT EE

EXISTING WASTEWATER TREATMENT PLANT PROCESS INFORMATION

Design Flow - 1.3 MGD

Normal Flow - 0.82 MGD

Flow During Pilot Operations - 0.86 MGD

Overflow Storage - 0.02 MG

Equalization

None

Neutralization

Acid Feed

Nutrient Addition

None

Screening

No. of Screens - 3

Size: 5' x 5' with 20/1000 inch mesh

Aeration Basin

No. of Basins - 1
Volume (Total) - 3 MG
Aeration (Total) - 320 Hp, 107 Hp/MG
Detention Time - 55 hrs. (at design flow)
88 hrs. (at normal flow)
84 hrs. (during pilot plant operations)

Secondary Clarifiers

No. of Clarifiers - 2
Size: Diameter - 55 ft (inside diameter)
SWD - 12 ft
Recycle Rate - 0.72 MGD (Total)

(continued)

TABLE C-37(EE)

(continued)

Sludge Thickening Facilities

Polymer Addition

Dissolved Air Flotation

Centrifuge

Foam Control

Antifoam added: a) Prior to aeration basin

b) To secondary clarifier overflow

EXISTING WASTEWATER TREATMENT PROCESS PERFORMANCE

The monthly operating data of the waste treatment plant, as reported by the plant, are shown in Appendix A for the one-year period immediately prior to and including the period of the pilot study. Daily operating data, as reported by the plant, are also presented in Appendix A. This data covers the period during which the pilot studies were in progress. The discharge values reported for the last year are compared to the BPT guideline values in Table C-38(EE). The effluent values reported in this table are final effluent numbers.

Plant EE experienced no serious operational problems during the pilot plant visit. There were a few instances of unusually high BPT effluent TSS concentrations. Based on visual ovservation by the field engineer, it is believed that these occurences were caused by algal build-up and sloughing on the secondary clarifier weirs. Steam cleaning of the weirs (a normal practice at Plant EE) was postponed so as not to interfere with pilot plant operation.

Based on the monthly averages over a twelve month period (June 1977 to May 1978) the plant was achieving 95 percent BOD_5 removal from an average influent BOD_5 of 404 mg/l to 20 mg/l. COD removal approximated 80 percent with reduction of the average influent of 1009 mg/l to 203 mg/l. The influent TSS level at Plant EE was low, averaging 27 mg/l with a removal efficiency of around 11 percent so that effluent TSS levels averaged 24 mg/l. During the same twelve month period, based on the data presented in Table C-38(EE) and Appendix E, the plant was within the BPT guidelines for all parameters. The mean cell residence time ranges from approximately one to ten days.

WATER USAGE

Based on an average wastewater flow of 0.857 MGD during the on-site study, 10.2 gallons of wastewater were generated per pound of finished material produced.

TABLE C-38(EE)

PLANT EE

COMPARISON OF ACTUAL PERFORMANCE TO BPT GUIDELINE VALUES

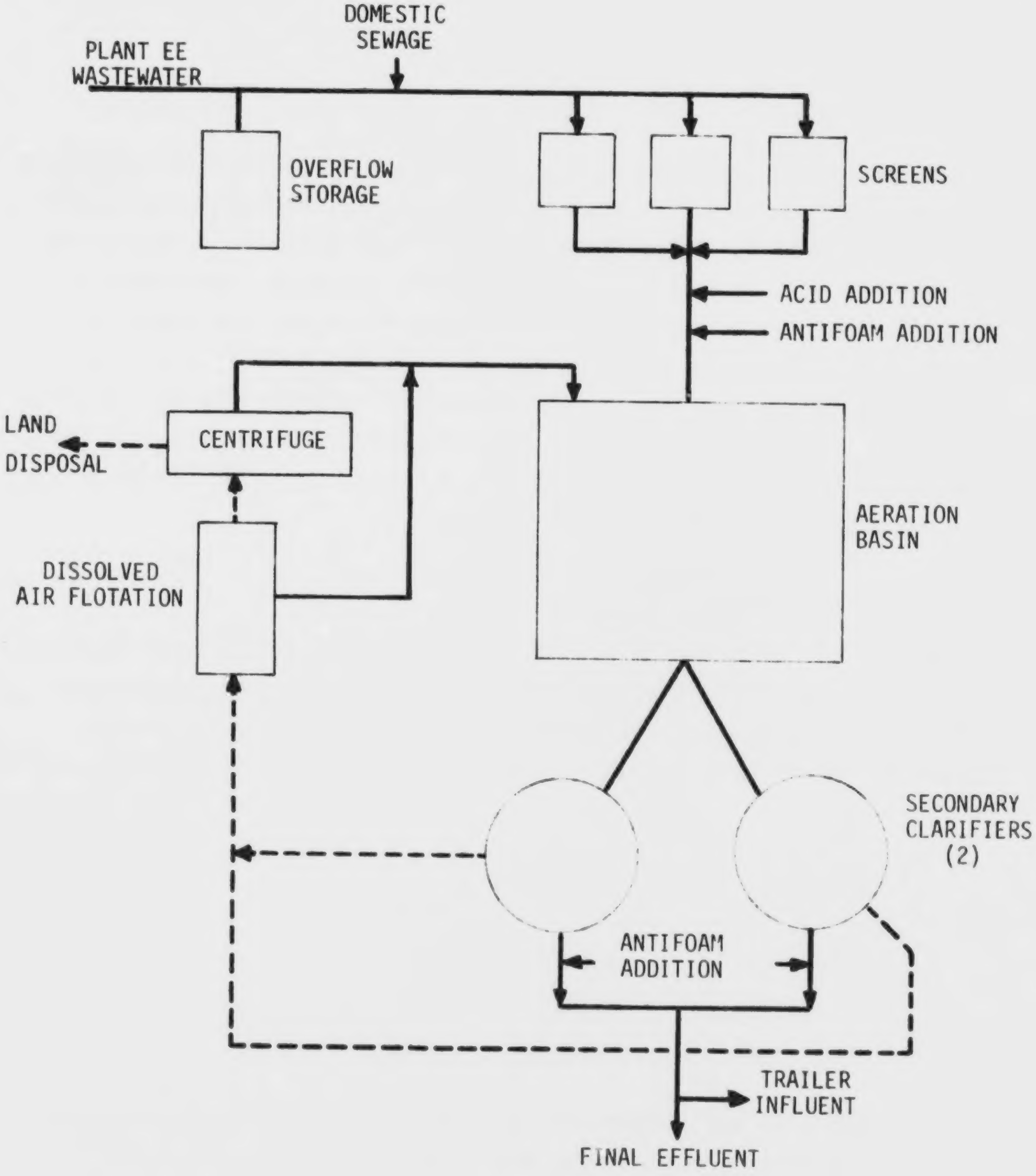
Parameter	BPT Guideline Values				Actual Operation June '77 - May '78	
	lbs/day(1)		mg/1 at 0.82 MGD(2)		mg/1	
	30-Day Avg.	Daily Max.	30-Day Avg.	Daily Max.	30-Day Avg. (3)	Daily Max.* (3)
BOD_5	319	637	47	93	12 - 27 (0)	19 - 43 (0)
COD	4157	314	608	1216	178 - 235 (0)	216 - 281 (0)
TSS	833	1667	122	244	11 - 44 (0)	30 - 98 (0)
Phenol	5.31	10.63	0.78	1.55	n.m.	n.m.
Chromium	5.31	10.63	0.78	1.55	n.m.	n.m.
Sulfide	10.63	21.26	1.55	3.11	n.m.	n.m.
Flow (MGD)	n.a.	n.a.	n.a.	n.a.	0.57 - 0.96	1.10 - 1.45
pH	------6.0 - 9.0------		-----6.0 - 9.0------		7.1 - 7.7 (0)	7.5 - 8.8 (0)

(1) See Appendix E for the calculations of the BPT Guideline Values.
(2) Average flow for the period of June '77 through May '78 as reported by the plant.
(3) The figures in parentheses represent the number of months in the 12-month period in which the plant monthly averages or maximums exceed the BPT Guidelines.
* These figures represent the range of monthly maximum values as reported by the plant.
n.a. not applicable.
n.m. not measured.

FIGURE C-20(EE)

SCHEMATIC FLOW DIAGRAM

EXISTING WASTEWATER TREATMENT FACILITIES AT PLANT EE


DOMESTIC SEWAGE
PLANT EE WASTEWATER
OVERFLOW STORAGE
SCREENS
ACID ADDITION
ANTIFOAM ADDITION
LAND DISPOSAL
CENTRIFUGE
AERATION BASIN
DISSOLVED AIR FLOTATION
SECONDARY CLARIFIERS (2)
ANTIFOAM ADDITION
TRAILER INFLUENT
FINAL EFFLUENT

APPENDIX D

ACTIVATED CARBON REGENERATION EXPERIMENTS

INTRODUCTION

One of the objectives of this study was to obtain information that would be helpful in predicting the potential for regeneration of activated carbon after being used to treat textile wastewater. When activated carbon exhaustion exceeds several hundred pounds per day at a treatment installation it is usually economically favorable to regenerate it rather than disposing of it. The relative success or failure of carbon regeneration is highly dependent on the quantity and nature of the impurities adsorbed onto the carbon (adsorbate). Since the amount and nature of adsorbate is dependent on the waste stream being treated, the relative ability to regenerate can differ between treatment applications.

EXPERIMENTAL CONDITIONS

Samples of activated carbon exhausted during pilot plant experimentation at 12 of the textile mills visited during this study were sent to Westvaco Corporation, Chemical Division in Covington, Virginia. Each sample was treated in a bench-scale thermal regeneration unit under the following conditions:

Temperature - 1650°F (900°C)
Time - 15 minutes
Stream Flow - 2 ml/minute
Air Flow - 200 ml/minute

RESULTS

The results of the regeneration experiments for the carbon used at 12 of the textile mills visited during this study are given in Tables D-1 and D-2. The results are expressed in terms of the sample properties defined and discussed below.

Apparent Density - Defined as the bulk unit weight of granular activated carbon dried at 100°C. The difference between the apparent density of virgin carbon and that of exhausted carbon gives an indication of the mass of impurities adsorbed onto the carbon during use. The difference in the apparent densities of the virgin and regenerated carbons indicates the degree to which the adsorbed substances were removed during regeneration. When examining apparent densities of virgin and regenerated carbon it should be noted that some carbon is lost during regeneration. In general, the closer the apparent density of the regenerated carbon to that of the virgin carbon, the more successful the regeneration.

Iodine Number - Defined as the mass of iodine adsorbed per mass of carbon from KI solution at an equilibrium filtrate concentration of 0.02N iodine. The Iodine Number is a good indicator of total internal surface area within the carbon grains down to pores as small as 10 Angstrom units in diameter. Since adsorptive capacity of carbon is highly dependent on internal pore area, the Iodine Number is a good indicator of restored adsorptive capacity upon regeneration. An increase in iodine number indicates an increase in adsorptive capacity.

Molasses Decolorizing Index - Defined as the ratio of molasses color capacity of a particular carbon to that of a standard carbon (x10). The Molasses Decolorizing Index affords a good measure of internal area of larger pores (28-32 Angstroms in diameter). In general, the Molasses Decolorizing Index of a given carbon will increase with increasing adsorptive capacity.

Ash Content - Defined as the residual material remaining after heating in a furnace at 600°C for an extended period of time (until all visable carbon grains have been burned away). The differences between the ash content of virgin, regenerated and exhausted carbon gives an indication of the relative amount of inert inorganic matter adsorbed during use and removed during regeneration.

TABLE D-1

GRANULAR CARBON REGENERATION TEST RESULTS FOR PLANTS WHERE WESTVACO NUCHAR WV-L ACTIVATED CARBON WAS USED

	Sample Properties				
				Ash Content	
Sample Identification	Apparent Density (lb/ft^3)	Iodine Number (mg/g)	Molasses Decolorizing Index	% Weight	lb/ft^3
Virgin Carbon	30.7	1151	10.8	7-8 (Typical)	2.15-2.46
PLANT A					
Spent Carbon	43.4	742	7.6	6.2	2.69
Regenerated Carbon	29.3	1094	14.9	8.5	2.49
PLANT V					
Spent Carbon	38.7	813	7.9	5.2	2.01
Regenerated Carbon	31.2	1124	9.3	6.2	1.93
PLANT W					
Spent Carbon	39.9	798	9.4	5.4	2.15
Regenerated Carbon	29.3	1264	13.7	7.5	2.20
PLANT Z					
Spent Carbon	34.9	860	7.6	5.9	2.06
Regenerated Carbon	30.6	1197	12.7	7.3	2.23
PLANT AA					
Spent Carbon	33.7	905	7.6	5.9	1.99
Regenerated Carbon	30.6	1184	11.6	6.8	2.08
PLANT E					
Spent Carbon	34.9	806	7.0	6.8	2.37
Regenerated Carbon	30.5	1151	14.2	8.6	2.62

TABLE D-1 (Continued)

GRANULAR CARBON REGENERATION TEST RESULTS FOR PLANTS WHERE WESTVACO NUCHAR WV-L ACTIVATED CARBON WAS USED

	Sample Properties				
				Ash Content	
Sample Identification	Apparent Density (lb/ft^3)	Iodine Number (mg/g)	Molasses Decolorizing Index	% Weight	lb/ft^3
Virgin Carbon	30.7	1151	10.8	7-8 (Typical)	2.15-2.46
PLANT EE					
Spent Carbon	35.6	767	7.0	7.7	2.74
Regenerated Carbon	31.2	1094	11.7	8.7	2.71
PLANT Y					
Spent Carbon	36.3	734	5.4	7.2	2.61
Regenerated Carbon	31.8	1006	7.4	8.1	2.58
PLANT O					
Spend Carbon	38.2	658	7.4	6.6	2.52
Regenerated Carbon	32.8	969	10.2	8.1	2.66
PLANT F					
Spent Carbon	36.7	686	6.1	5.8	2.13
Regenerated Carbon	31.2	1013	10.2	6.7	2.09

TABLE D-2

GRANULAR CARBON REGENERATION TEST RESULTS FOR PLANTS WHERE ICI HYDRODARCO 3000 ACTIVATED CARBON WAS USED

	Sample Properties				
				Ash Content	
Sample Identification	Apparent Density (lb/ft^3)	Iodine Number (mg/g)	Molasses Decolorizing Index	% Weight	lb/ft^3
Virgin Carbon (typical values)	23-24	550-650	Not Available	10-18	2.3-4.3
PLANT K					
Spent Carbon	25.3	420	6.5	10.5	2.66
Regenerated Carbon	22.9	639	16.3	12.0	2.75
PLANT T					
Spent Carbon	26.0	489	8.8	11.4	2.96
Regenerated Carbon	24.6	634	15.0	12.9	3.17

DISCUSSION OF RESULTS

Relationships between virgin, regenerated, and exhausted carbon properties for the two activated carbons used during this study are given in Table D-3. The information presented is based on averages derived from the data in Tables D-1 and D-2.

Examination of the apparent density relationships for the two carbons (Table D-3) shows that on the average Westvaco carbon adsorbed significantly more matter during use than the ICI carbon. An average of 6.5 lb/ft adsorbate was measured on the Westvaco carbon while 2.2 lb/ft^3 was measured on the ICI carbon. Successful single cycle regeneration of both carbons is indicated based on the fact that the regeneration process reduced the apparent densities of the exhausted carbons to within approximately 1% of the apparent densities of the virgin carbons. It should be noted here that the difference in apparent densities of the virgin and regenerated carbons cannot be taken as a strict measurement of adsorbate remaining after regeneration due to carbon losses during the regeneration process.

The relationships given based on Iodine Number (Table D-3) show a greater average loss in adsorptive capacity of the Westvaco carbon during use than loss in adsorptive capacity of the ICI carbon during use. The difference between the iodine adsorption capacity of the regenerated and virgin carbons was less with the ICI carbon. Based on percent reduction in iodine adsorption capacity after use and percent returned through regeneration it can be seen that the two carbons behaved very similarly. Good single cycle regenerability of the carbons is indicated by only a 2-4% decrease in iodine adsorption capacity as a result of treatment use followed by regeneration.

Virgin carbon Mollasses Decolorizing Index information was available only for the Westvaco carbon. The relationships given in Table D-3 show an average occupancy of 32% of the adsorptive area within the larger pores (28-32 Angstroms) of the exhausted activated carbon. An increase of 7% in the Molasses Decolorizing Index of the regenerated carbon over the virgin carbon shows an increase in large pore area due to regeneration. The Molasses Decolorizing Index data indicates a good return of adsorptive capacity as a result of single-cycle regeneration.

TABLE D-3

RELATIONSHIPS BETWEEN VIRGIN, REGENERATED, AND EXHAUSTED WESTVACO NUCHAR WV-L AND ICI HYDRODARCO 3000 ACTIVATED CARBONS*

	WESTVACO NUCHAR WV-L	ICI HYDRODARCO 3000
APPARENT DENSITY (lb/ft^3)		
Difference between Virgin and Exhausted	6.5	2.2
Difference between Virgin and Regenerated	0.15	0.25
Percent Increase of Exhausted over Virgin	21	10
Percent Increase of Regenerated over Virgin	1	1
IODINE NUMBER (mg/g)		
Difference between Virgin and Exhausted	374	196
Difference between Virgin and Regenerated	41	14
Difference between Regenerated and Exhausted	333	182
Exhausted Percent of Virgin	68	70
Regenerated Percent of Virgin	96	98
MOLASSES DECOLORIZING INDEX		
Difference between Virgin and Exhausted	3.5	-
Difference between Virgin and Regenerated	-0.8	-
Difference between Regenerated and Exhausted	4.3	8.0
Exhausted Percent of Virgin	68	-
Regenerated Percent of Virgin	107	-

The results of the single cycle regeneration experiments indicate that the two carbons used during this study can potentially be regenerated after being used in AWT applications on textile plant wastewaters. A test including six to eight regeneration cycles would be required to conclusively state that regeneration of carbon from textile wastewater treatment was successful on a technical and practical basis.

APPENDIX E

BENCH SCALE ACTIVATED SLUDGE WITH ACTIVATED CARBON TREATMENT

CONCLUSIONS AND RECOMMENDATIONS

The bench scale studies of powdered activated carbon addition to the activated (PAC) process have been completed for 10 textile plants representing six EPA subcategories. It is important to emphasize that the purpose of this study was to obtain an indication of the feasibility of applying this method of treatment in order to achieve BATEA technical effluent limitations and decide if full-scale evaluations should be instituted for specific subcategories.

The information generated during this study and presented in this report from the basis for the following conclusions and recommendations.

CONCLUSIONS

1. PAC treatment was generally successful in improving the effluent quality in bench scale evaluations of wastes from EPA textile Subcategories II, IV, V, VI and VII.
2. Subcategory I (Plant A) - BOD_5 and COD were not significantly affected by the PAC treatment. PAC at the high dosage did effect good color removal. Chrome and phenol data were either unavailable or inconclusive. Sulfides levels were not significantly affected.
3. Subcategory II (Plants B and O) - PAC treatment was generally effective for BOD_5, COD, and color. Phenols were not affected by PAC. Sulfides were reduced approximately half at very low concentrations. Some reduction, although inconsistent, was noted for total chromium.
4. Subcategory IV (Plants D, P and Y) - Plant D is not considered to be typical or representative of Subcategory IV plants. The conclusions are based therefore on Plants P and Y. COD and BOD_5 BATEA limits were achieved by the control reactors. Further reductions were achieved for COD by the low level (19-39%) and high level (31-62%) carbon reactors. No effect noted for phenols. Inconclusive results were noted for sulfides. Color levels were generally reduced by both low and high levels.

5. Subcategory V (Plants E and Q) - PAC treatment was consistently effective for COD with lesser effect on BOD_5. Inconclusive results were observed for sulfide and chrome. Phenol values were all below the detectable limit. Color removal was generally effective for both plants.

6. Subcategory VI (Plant F) - BOD_5, COD and color were effectively treated by the PAC process. Phenols and sulfides were below the detectable limit. Chrome results were inconclusive.

7. Subcategory VII (Plant S) - COD and color were effectively treated by the PAC process. BOD_5 was not significantly affected. Chrome and sulfide values were reduced although reductions were not as great as for COD and color. Phenols were below the detectable limits.

8. A summary comparing the results with the estimated BATEA values is presented in Table E-1.

RECOMMENDATIONS

1. Due to the relative percentage of textile wet processing in Subcategories IV and V and the effectiveness of PAC on bench scale it is recommended that full-scale PAC testing be conducted at one plant in each subcategory.

2. If time and budget constraints permit full scale testing should also be performed on a plant in Subcategory VI.

3. Due to the importance of the effect of any candidate BATEA process on priority pollutants it is recommended that at least a minimal level of analyses for these compounds be included in the full scale PAC testing.

TABLE E-1

PAC ACHIEVEMENT OF BATEA LIMITATIONS FOR EACH SUBCATEGORY

	Carbon Level	BOD_5	TSS	COD	Cr	Phenol	Sulfide	Color	Remarks
SUBCATEGORY I									
Plant A	**High** (10,000 mg/l)	No	No	No	-	Yes	No	Yes	Excess oil and grease hindered PAC process
	Low (2,000 mg/l)	No	No	No	-	Yes	No	No	
SUBCATEGORY II									
Plant B	**High** (8,000 mg/l)	Yes	No	Yes	Incon.	Yes	Incon.	Yes	Pac was an effective process
	Low (2,000 mg/l)	Incon.	No	Yes	Yes	Yes	No	Yes	
Plant O	High (5,000 mg/l)	Yes	Yes	Yes	Yes	Yes	Incon.	Yes	Some foaming tendencies related to carbon additions
	Low (1,000 mg/l)	Yes	Incon.	Yes	Yes	Yes	No	Yes	
SUBCATEGORY IV									
Plant P	**High** (5,000 mg/l)	Yes	Yes	Yes	Yes	Yes	Yes	Incon.	Effective method with exception of Plant D
	Low (1,000 mg/l)	Yes	No	Yes	Yes	Yes	No	Incon.	
Plant D	**High** (6,000 mg/l)	Yes	Incon.	No	-	Yes	-	No	Plant D improved by use of PAC but did not meet BATEA Limits. Plant D very dark waste with high organic loading.
	Low (3,000 mg/l)	Yes	No	No	-	Yes	-	No	
Plant Y	**High** (5,000 mg/l)	Yes	No	Yes	-	Yes	No	Yes	
	Low (2,000 mg/l)	Yes	No	Yes	-	Yes	No	Yes	
SUBCATEGORY V									
Plant E	**High** (5,000 mg/l)	No	No	Yes	-	Yes	Yes	Yes	Pac was an effective process
	Low (2,000 mg/l)	No	No	Incon.	-	Yes	Yes	Yes	
Plant Q	**High** (5,000 mg/l)	Yes	Incon.	Yes	Yes	Yes	No	Yes	High carbon concentration achieved BATEA limits at Plant Q
	Low (1,000 mg/l)	Yes	Yes	No	Yes	Yes	No	No	
SUBCATEGORY VI									
Plant F	**High** (5,000 mg/l)	Yes	Incon.	Yes	No	Yes	Yes	Yes	Pac was an effective process
	Low (2,000 mg/l)	Yes	No	Yes	Yes	Yes	Yes	Incon.	
SUBCATEGORY VII									
Plant S	High (5,000 mg/l)	Yes	No	Yes	Yes	Yes	Yes	Yes	Pac was an effective process High carbon concentration achieved BATEA limits at Plant S
	Low (2,000 mg/l)	Incon.	No	No	Yes	Yes	Incon.	Yes	

Yes - PAC $\bar{x} + 1\sigma \leq$ BATEA limits

No - PAC $\bar{x} >$ BATEA limits

Inconclusive ("Incon") - PAC $\bar{x} <$ BATEA limits $<$ PAC $\bar{x} + 1\sigma$

APPENDIX F

COST ESTIMATING PROCEDURE FORMS

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Cost Estimating Program for Advanced Waste Treatment of Textile Wastewater Page 339

ADVANCED WASTE TREATMENT

PROCESS SELECTION AND PROCESS DESIGN

TEXTILE

SUBCATEGORY IV

WOVEN FABRIC FINISHING

BATEA STUDY

Sponsored by: ATMI/NTA/CRI and EPA

Plant:______________________________

Address:______________________________

____

Phone No:______________________________

Prepared By:______________________________

Date:______________________________

INTRODUCTION

The objective of this program is to allow you to determine a hypothetical process selection and establish process design information for any Advanced Wastewater Treatment (AWT) facilities that may be anticipated for your plant to achieve the presently promulgated BATEA effluent guideline limitations. You must complete this worksheet packet prior to initiation of your cost estimate.

This program is set up for Subcategory IV plants with secondary biological treatment defined as Best Practicable Treatment (BPT). The AWT processes described are for additional wastewater treatment of a BPT effluent.

In order to complete this worksheet packet you should have the following information:

Average* production in pounds per work day

Average* waste treatment plant effluent values for:

Flow in million gallons per work day (MGD)
Biochemical Oxygen Demand (BOD_5), mg/l
Chemical Oxygen Demand (COD), mg/l
Total Suspended Solids (TSS), mg/l
Phenol, mg/l
Sulfide, mg/l
Chromium, mg/l
Color, ADMI units

This program includes a three step procedure to define your treatment objectives, select a hypothetical AWT system for your plant and size the AWT process(es) selected. The procedure was developed from experimental results of the ATMI/EPA pilot plant study and provides a method of predicting an AWT system based on your type production and BPT effluent quality. This does not guarantee that the AWT system is correctly defined. Indeed an experimental study with your particular wastewater would be required to adequately define an AWT system at your plant.

*Select a time period that is representative of normal production and waste treatment plant operation. Use the same period for both averages.

The steps you will follow in this program are summarized below:

1) Establish your BATEA treatment objectives,

2) Select the recommended AWT system for your plant and

3) Establish process design criteria for the selected AWT system.

After completing this worksheet packet you can initiate your cost estimate as defined in the Cost Estimating Program for Advanced Waste Treatment of Textile Wastewater.

STEP 1 - ESTABLISH BATEA TREATMENT OBJECTIVES

Average* production - ________ in 1000 lbs per work day

Average* flow - ________ in million gallons per work day (MGD)

BATEA Treatment Requirements:

TABLE 1

	(A)	(B)	(C)	(D)
	lbs Pollutant(1)	BATEA Guideline Values		BPT Effluent(4)
Parameter	1000 lbs Product	lbs/day(2)	mg/l(3)	mg/l
BOD_5	2.2			
TSS	1.5			
COD	10(5)	(5)		
Total Chromium	0.05			
Phenol	0.05			
Sulfide	0.10			
Color (ADMI units)	-	(300 ADMI units)		

(1) From Federal Register, 5 July 1974, 39 #130, BATEA guideline values for 30-day average, Subcategory D (IV) Woven Fabric Finishing.

(2) To calculate the BATEA guideline values in lbs/day, column (B), multiply the value in column (A) by the average production value in 1000 lbs per work day.

(3) To calculate the BATEA guideline values in mg/l, column (C), divide the value in column (B) by the factor (8.34 lb/gal x average flow in MGD).

(4) List the average* effluent values from your waste treatment plant.

(5) Additional COD limitations allowed for:

Woven Fabric Finishing through--

Simple process with synthetic fiber or Complex process with natural fiber	3.3 lb/1000 lb
Simple process with natural/synthetic blend or Complex process with synthetic fiber	6.7 lb/1000 lb
Complex process with natural/synthetic blend	10.0 lb/1000 lb

*See note on page 1

Treatment Objective:

To establish your treatment objectives, compare the BATEA values in Table 1, column (C) with your present effluent values in Table 1, column (D). If your effluent value for a particular parameter is less than the BATEA value, then no additional treatment is needed. If your effluent value is greater than the BATEA value, than additional treatment is required for reduction of that parameter. List treatment objectives below:

TABLE 2

Parameter(1)	(A) BPT(2) Value mg/l	(B) BATEA(3) Value mg/l	(C) % Reduction Required(4)

(1) List only those parameters which will require additional treatment.

(2) Average effluent values for waste treatment plant as listed in Table 1, column (D).

(3) BATEA values as listed in Table 1, column (C).

(4) Calcualte column (C), % Reduction Required as follows:

$$(C) = \frac{(A) - (B)}{(A)} \times 100$$

Do you qualify as a commission finisher as defined by EPA?

Yes No (Circle One)

Would you qualify if it were not for the ownership restriction?

Yes No (Circle One)

STEP 2 - SELECT THE RECOMMENDED AWT SYSTEM

There are four AWT processes that are applicable to Subcategory IV plants; coagulation/clarification, multi-media filtration, granular carbon adsorption and ozonation. Determine which AWT process or processes are required at your plant according to the treatment objective established in Step 1 and the guidelines listed below.

To Reduce	Recommended AWT Process(es)
TSS	
If BPT value, Table 2, column (A), is less than 100 mg/l; then select	Either Multi-Media Filtration or Multi-Media Filtration with Precoagulation
If BPT value, Table 2, column (A), is greater than 100 mg/l; then select	Coagulation/clarification followed by Multi-Media Filtration
BOD_5	
If % reduction required, Table 2, column (C), is less than 15%; then select	Multi-Media Filtration with Precoagulation
If % reduction required, Table 2, column (C), is greater than 15%, then select	Multi-Media Filtration followed by Granular Carbon Adsorption
COD	
If % reduction required, Table 2, column (C), is less than 10%; then select	Multi-Media Filtration with Precoagulation
If % reduction required, Table 2, column (C), is less than 50%; but greater than 10%; then select	Multi-Media Filtration followed by Granular Carbon Adsorption
If % reduction required, Table 2, column (C), is greater than 50%; then select	Multi-Media Filtration followed by Granular Carbon Adsorption followed by Ozone
Color	
If % reduction required, Table 2, column (C), is less than 5%; then select	Multi-Media Filtration with Precoagulation

If % reduction required, Table 2, column (C), is less than 20%, but greater than 5%; then select------------------Multi-Media Filtration followed by Granular Carbon Adsorption

If % reduction required, Table 2, column (C), is greater than 20%; then select-----------Multi-Media Filtration followed by Granular Carbon Adsorption followed by Ozonation.

Phenol. Chromium, Sulfide

then select---------------------Multi-Media Filtration followed by Granular Carbon Adsorption

Review your treatment objectives and AWT processes that are recommended, then select one of the following AWT Process Systems for your plant.

AWT Process System A-2

Multi-Media Filtration

(Conceptual Process Flow Diagram - Figure 3)

AWT Process System A-4

Coagulation/clarification followed by Multi-Media Filtration

(Conceptual Process Flow Diagrams - Figures 1 and 2)

AWT Process System A-8

Multi-Media Filtration followed by Granular Carbon Adsorption

(Conceptual Process Flow Diagrams - Figures 3 and 4)

AWT Process System A-9

Coagulation/clarification followed by Multi-Media Filtration followed by Granular Carbon Adsorption

(Conceptual Process Flow Diagrams - Figures 1, 2 and 4)

AWT Process System A-3

Multi-Media Filtration with Precoagulation

(Conceptual Process Flow Diagram - Figure 5)

AWT Process System A-10

Multi-Media Filtration followed by Granular Activated Carbon Adsorption followed by Ozonation

(Conceptual Process Flow Diagrams - Figures 3, 4 and 6)

AWT Process System A-11

Coagulation/clarification followed by Multi-Media Filtration followed by granular activated carbon adsorption followed by ozonation.

(Conceptual Process Flow Diagrams - Figures 1, 2, 4, and 5)

The Conceptual Process Flow Diagrams are provided as supplimental information on the AWT processes.

STEP 3 - ESTABLISH PROCESS DESIGN CRITERIA FOR SELECTED AWT SYSTEM

Process design information is required for the AWT system you have selected in order to develop the cost estimate. The following procedure is intended to aid you in establishing process design criteria. Complete only the sections that apply based on your AWT process selection.

Design Flow (Applies to all Processes)

Average plant flow - _________ in MGD

Backwash flow - _________ MGD - If A-2, A-3 or A-4, 5% of avg. flow. If A-8, A-9, A-10 or A-11, 10% of avg. flow.

Design flow - _________ MGD (sum of avg. and backwash flows)

Coagulation/clarification (Reactor/Clarifier Unit) - Applies to Processes A-4, A-9, and A-11

Design flow: _______ MGD

Design overflow rate: 300 gpd/ft^2

Coagulant: 20 mg/l cationic polymer

Clarifier surface area:

$$\text{Surface Area} = \frac{(\text{Design Flow, MGD}) \times 10^6}{\text{Overflow rate, gpd/ft}^2} \times \text{Underflow recycle factor}$$

$$\text{Surface Area} = \frac{\underline{\quad\quad}\ \text{MGD} \times 10^6}{300\ \text{gpd/ft}^2} \times 1.25 \quad \underline{\underline{\quad\quad\quad}}\ \text{ft}^2$$

Sludge production:

(Inf. TSS$^{(1)}$ - Eff TSS) x Design Flow x 8.34 lb/gal = sludge in lb/day

(______ mg/l - 100 mg/l) x ______ MGD x 8.34 = ______ lb/day sludge

Coagulant Usage:

Cationic polymer = concentration, mg/l x des. flow, MGD x 8.34 lb/gal

20 mg/l x ________ MGD x 8.34 lb/gal = ________ lb/day

(1) Table 1, Column (D), BPT TSS value

Multi-Media Filtration - Applies to Processes A-2, A-4, A-8, A-9, A-10 and A-11

Design flow: ______MGD

Surface loading rate: 2 gpm/ft^2

Filter area:

$$\text{Area} = \frac{\text{Design Flow, MGD} \times 10^6}{\text{Surface Loading Rate, gpm/ft}^2 \times 24 \text{ hr/day} \times 60 \text{ min/hr}}$$

$$\text{Area} = \frac{\underline{\qquad}\text{MGD} \times 10^6}{2 \text{ gpm/ft}^2 \times 24 \text{ hr/day} \times 60 \text{ min/hr}} = \underline{\underline{\qquad\quad}} \text{ ft}^2$$

Granular Carbon Adsorption - Applies to Processes A-8, A-9, A-10 and A-11

Design flow: ______MGD

Carbon capacity: 0.75 lb COD/lb carbon

COD removed:

(Inf COD(2) - Eff COD(3)) x Design Flow MGD x 8.34 lb/day = lb/day COD removed

$$(\underline{\qquad}\text{mg/l} - \underline{\qquad}\text{mg/l}) \times \underline{\qquad}\text{MGD} \times 8.34 \text{ lb/gal} = \underline{\underline{\qquad\quad}} \text{ lb/day COD removed}$$

(2) From Table 1, Column (D), BPT COD value

(3) BATEA COD value from Table 1, Column (C).

Carbon usage:

$$\frac{\text{lb/day COD removed}}{\text{carbon capacity, lb COD/lb carbon}} = \text{lb/day carbon}$$

$$\frac{\underline{\qquad}\text{lb/day COD removed}}{0.75 \text{ lb COD/lb carbon}} = \underline{\underline{\qquad\quad}} \text{ lb/day carbon}$$

Adsorber volume required:

$$\frac{\text{Design flow, MGD} \times 10^6 \times 1.5}{1440 \text{ min/day} \times 7.48 \text{ gal/ft}^3} \times 45 \text{ min} = \text{volume, ft}^3$$

$$\frac{\underline{\qquad}\text{MGD} \times 10^6 \times 1.5}{1440 \text{ min/day} \times 7.48 \text{ gal/ft}^3} \times 45 \text{ min} = \underline{\underline{\qquad\quad}} \text{ ft}^3 \text{ adsorber volume}$$

Multi-Media Filtration with Precoagulation - Applies to Process A-3

Design flow: ________MGD

Surface Loading Rate: 2 gpm/ft^2

Coagulant: Alum at 15 mg/l as Al^{+3}

Filter Area:

$$\text{Area} = \frac{\text{Design Flow, MGD} \times 10^6}{\text{Surface Loading Rate, gpm/ft}^2 \times 24 \text{ hr/day} \times 60 \text{ min/hr}}$$

$$\text{Area} = \frac{\underline{\qquad}\text{MGD} \times 10^6}{2 \text{ gpm/ft}^2 \times 24 \text{ hr/day} \times 60 \text{ min/hr}} = \underline{\underline{\qquad\qquad}} \text{ ft}^2$$

Coagulant usage:

Alum = concentration, mg/l x des. flow, MGD x 8.34 lb/gal

15 mg/l x _____MGD x 8.34 lb/gal = ________lb/day as Al^{+3}

Ozonation - Applies to Processes A-10 and A-11

Design flow: _____MGD

Ozone Dosage: 400 mg/l (utilized)

Ozone Efficiency: 90%

Contact Time: 30 minutes

Contactor Volume:

$$\text{Volume} = \frac{\text{Flow, MGD} \times 10^6 \times 30 \text{ min}}{1440 \text{ min/day} \times 7.48 \text{ gal/ft}^3} = \qquad \text{ft}^3$$

$$\text{Volume} = \frac{\underline{\qquad}\text{MGD} \times 10^6 \times 30 \text{ min}}{1440 \text{ min/day} \times 7.48 \text{ gal/ft}^3} = \underline{\underline{\qquad\qquad}}\text{ft}^3$$

Ozone Required:

$$\frac{400 \text{ mg/l} \times \underline{\qquad} \text{ MGD} \times 8.34 \text{ lb/day}}{0.9 \text{ efficiency}} = \underline{\underline{\qquad\qquad}} \frac{\text{lb}}{\text{day}} O_3$$

COST ESTIMATING PROGRAM
FOR ADVANCED WASTE TREATMENT
OF TEXTILE WASTEWATER

BATEA STUDY

Sponsored by: ATMI/NTA/CRI and EPA

Plant:__________________________________

Address:________________________________

____

Phone No:_______________________________

Prepared By:____________________________

Date:___________________________________

INTRODUCTION

The purpose of this cost estimating program is to provide a method for estimating both the capital and the operation and maintenance costs for the Advanced Waste Treatment (AWT) you have selected for your plant. You must complete the AWT Process Selection and Process Design Program before initiating your cost estimate. The process design criteria from Step 3 of the AWT Process Selection and Process Design Program will be utilized in developing your cost estimate. You should summarize the process design information in the Table 1 on the following page. Complete only the information that applies to processes you have selected.

The estimating program is divided into three parts as follows:

Part I - Equipment Selection and Sizing

Part II - Capital Cost Estimate

Part III - Operation and Maintenance Costs

A list of Figures is included in Table 2 to help you locate specific information.

TABLE I

PROCESS DESIGN INFORMATION SUMMARY

GENERAL PLANT INFORMATION

Selected AWT Process System A-____

Design Flow _____ MGD

Average Flow _____ MGD

Backwash Flow _____ MGD

SELECTED UNIT PROCESSES

1. Multi-Media Filtration

Surface Area _____ ft^2

1A. Multi-Media Filtration with Precoagulation

Surface Area _____ ft^2

Coagulant Usage
Alum ______ lb/day as Al^{+3}

2. Coagulation/clarification

Surface Area _____ ft^2

Sludge Production _____ lb/day sludge

Coagulant Usage
Alum _____ lb/day as Al^{+3}
Cationic Polymer ______ lb/day

3. Granular Carbon Adsorption

Carbon Usage ______ lb/day

Adsorber volume ______ ft^3

(Bed volume = $\frac{\text{Adsorber volume}}{1.5} = \frac{\_\_\_\_\_\_ \ ft^3}{1.5} = \_\_\_\_\_\_\_\_ \ ft^3$)

4. Ozonation

Contactor Volume ______ ft^3

Ozone Required _______ lb/day

Note: Information for completing this table should be obtained from Step 3 of the AWT Process selection and Process Design Program

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TABLE 2

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PART I

EQUIPMENT SELECTION AND SIZING

PART I

EQUIPMENT SELECTION AND SIZING

Each AWT system is comprised of one or more of four unit processes. Eleven possible AWT systems are illustrated in the A series figures, A-1 through A-11. The AWT system which you have selected should be included as one of the eleven possible systems. The following list indicates the figure numbers and corresponding AWT system.

FIGURE NO.	AWT SYSTEM
A-1	Reactor Clarifier
A-2	Multi-Media Filter
A-3	Multi-Media Filter w/Precoagulation
A-4	Reactor Clarifier and Multi-Media Filter
A-5	Multi-Media Filter and Ozone
A-6	Reactor Clarifier and Ozone
A-7	Reactor Clarifier and Multi-Media Filter and Ozone
A-8	Multi-Media Filter and Granular Activated Carbon Adsorption
A-9	Reactor Clarifier and Multi-Media Filter and Granular Activated Carbon Adsorption
A-10	Multi-Media Filter and Granular Carbon Adsorption and Ozone
A-11	Reactor Clarifier and Multi-Media Filter and Granular Carbon Adsorption and Ozone

These figures show "idealized" or conceptual site layouts for the major equipment and structures necessary for each AWT system.

Equipment size, quantity selection and specific equipment dimensions for the four unit processes included within the AWT systems are presented in the B series figures, B-1 through B-5. These are also based on idealized situations. The following table indicates the figure numbers and corresponding unit processes.

FIGURE NO.	UNIT PROCESS
B-1	Multi-Media Filter
B-2.1	Reactor Clarifier
B-2.2	Reactor Clarifier Sludge Handling Facilities
B-3	Granular Carbon Adsorption
B-4	Ozonation
B-5	Chemical Handling Facilities

The table shown on each B series illustration titled "Unit Configuration Selection" provides a method of estimating the number of units required and the range of sizes for each unit. After establishing the number and size of units required additional tables are provided on the figures illustrating some typical unit dimensions and operating weights. The information provided is for idealized conditions and specific site application may affect both the number and size of equipment.

As an example to demonstrate the use of the Equipment Selection and Sizing guidelines, an AWT system employing a multi-media filter will be examined. It will be assumed that after completing the Process Design Program a filter of 400 square feet is required. The "Unit Configuration Selection" table on Figure B-1 recommends a 6 cell filter with a surface area per cell of A/5, or in this case, 80 square feet (A is the required area, 400 square feet). For 6 cells this yields a total filter surface area of 6 x 80 or 480 square feet. The unit dimensions and weights for a 6 cell-480 square foot filter may now be identified from the "Typical Unit Dimensions" table on the same figure. Your selection of size may not fit one of the typical unit dimensions but this is not essential. The typical unit dimensions are provided as suplimental information for developing a site specific layout.

Space has been provided on each of the B series figures for you to include your calculations.

REACTOR CLARIFIER
CONCEPTUAL LAYOUT

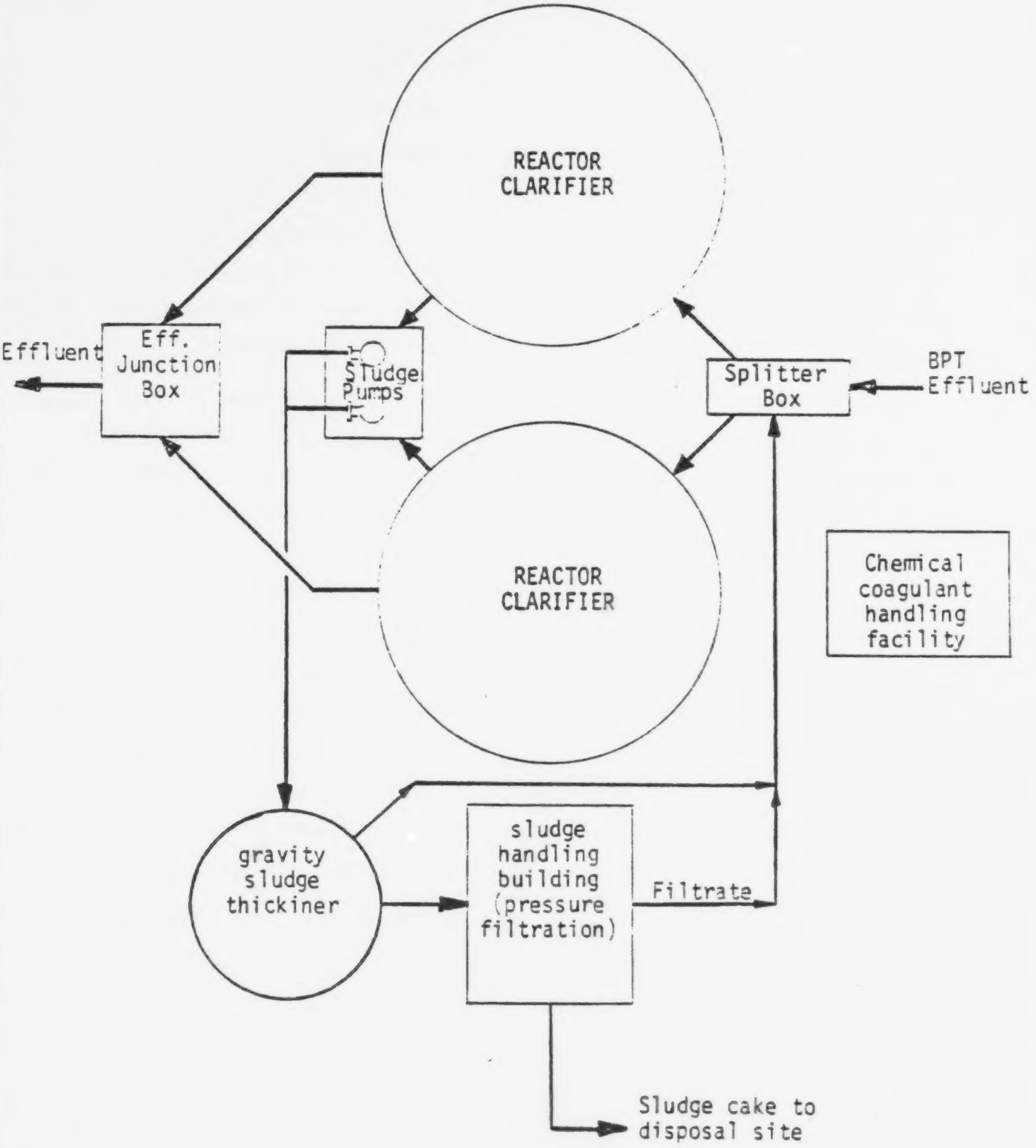
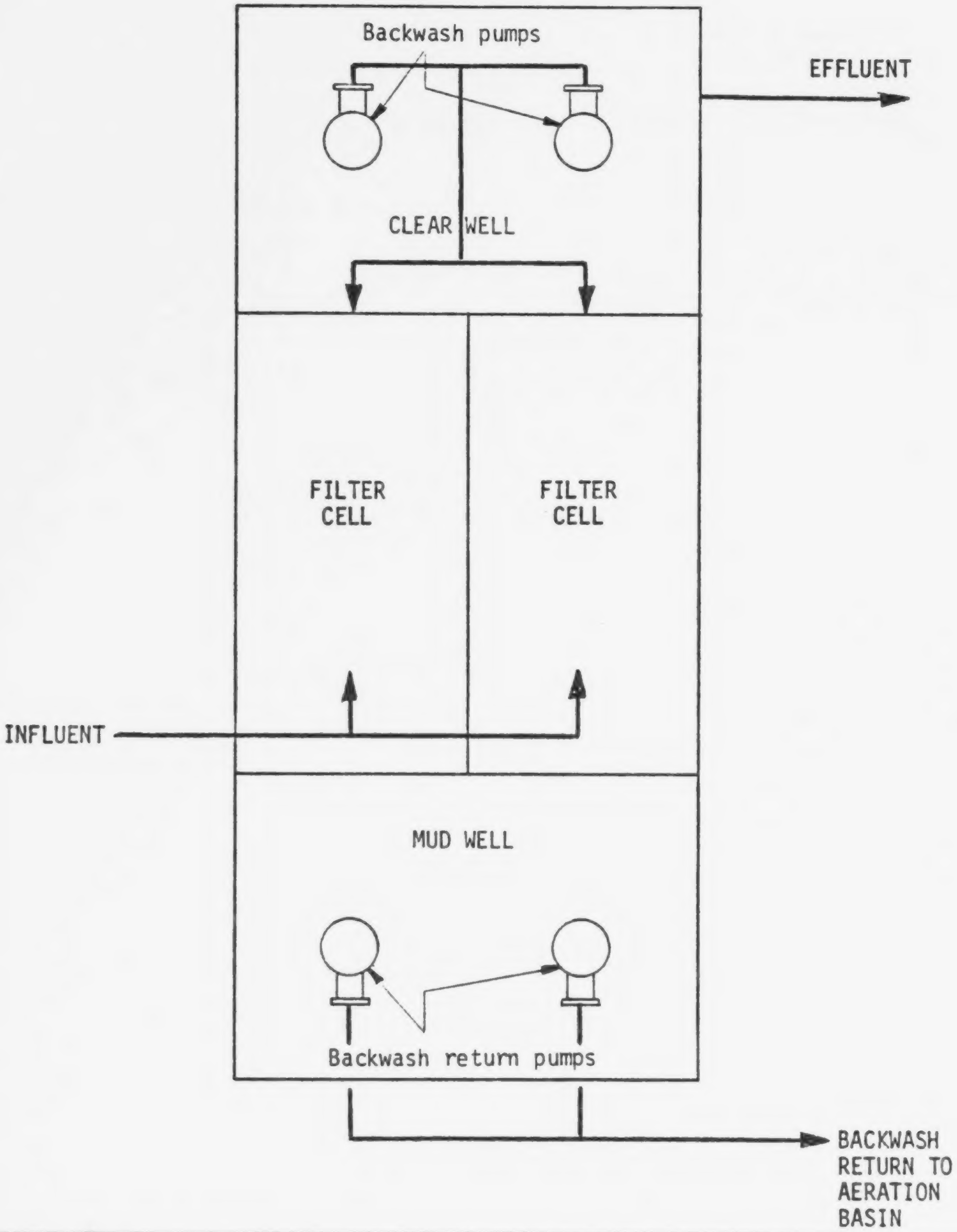

REACTOR CLARIFIER
Effluent
Eff. Junction Box
Sludge Pumps
Splitter Box
BPT Effluent
REACTOR CLARIFIER
Chemical coagulant handling facility
gravity sludge thickiner
sludge handling building (pressure filtration)
Filtrate
Sludge cake to disposal site

FIGURE A-2

MULTI-MEDIA FILTRATION
CONCEPTUAL LAYOUT


Backwash pumps
EFFLUENT
CLEAR WELL
FILTER CELL
FILTER CELL
INFLUENT
MUD WELL
Backwash return pumps
BACKWASH RETURN TO AERATION BASIN

MULTI-MEDIA FILTRATION WITH PRECOAGULATION

CONCEPTUAL LAYOUT

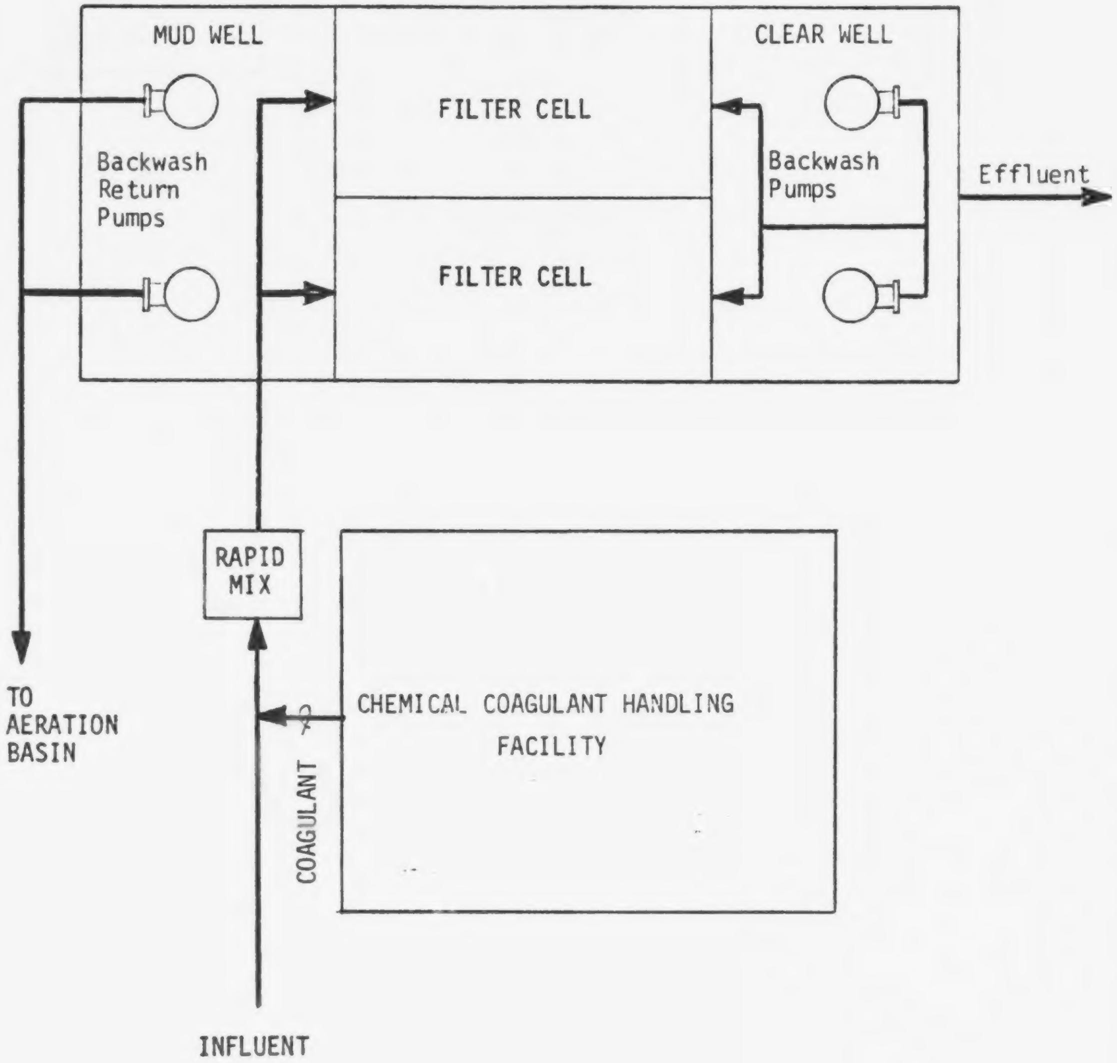

MUD WELL
FILTER CELL
CLEAR WELL
Backwash Return Pumps
Backwash Pumps
Effluent
FILTER CELL
RAPID MIX
TO AERATION BASIN
CHEMICAL COAGULANT HANDLING FACILITY
COAGULANT
INFLUENT

FIGURE A-4

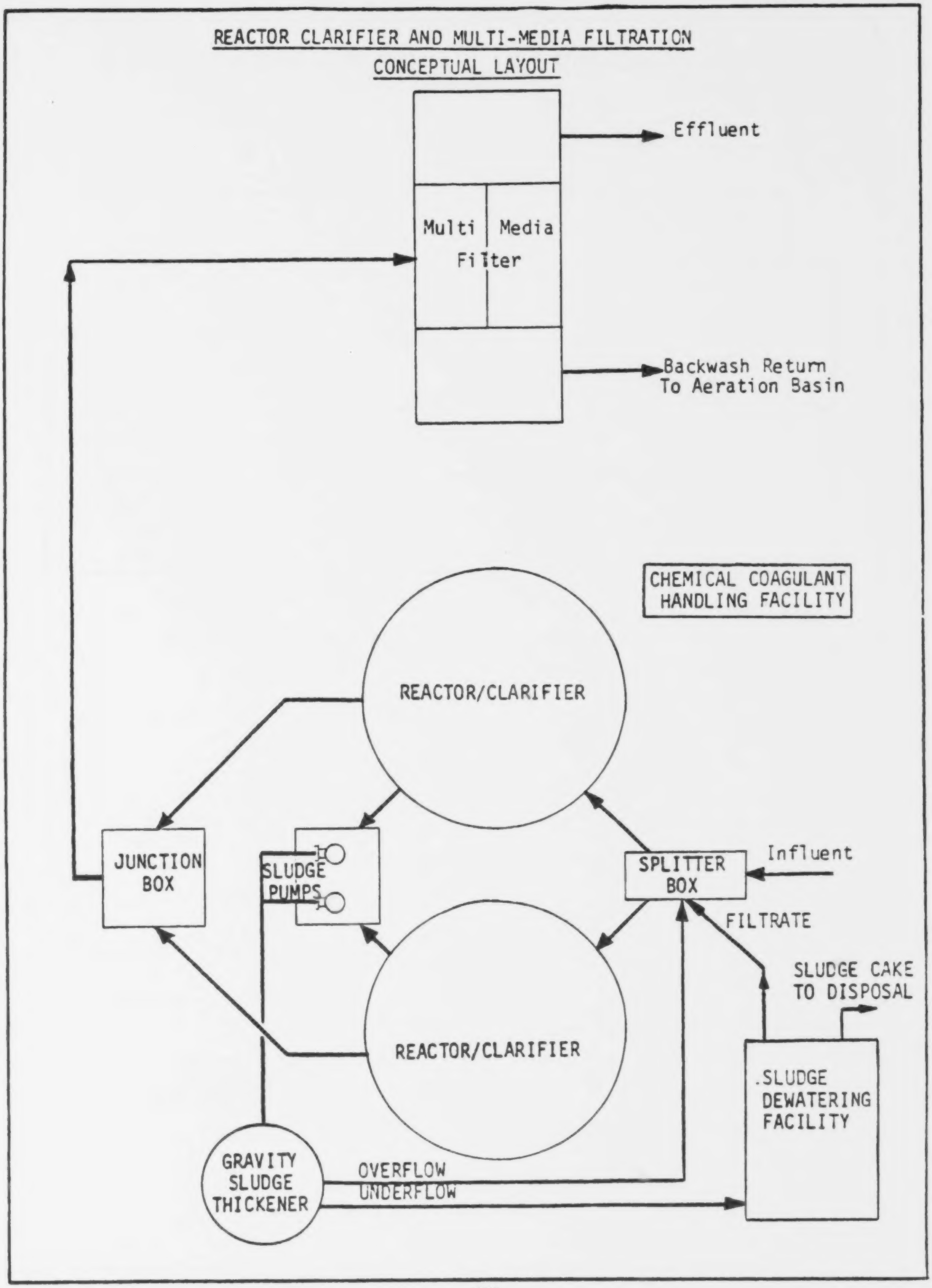
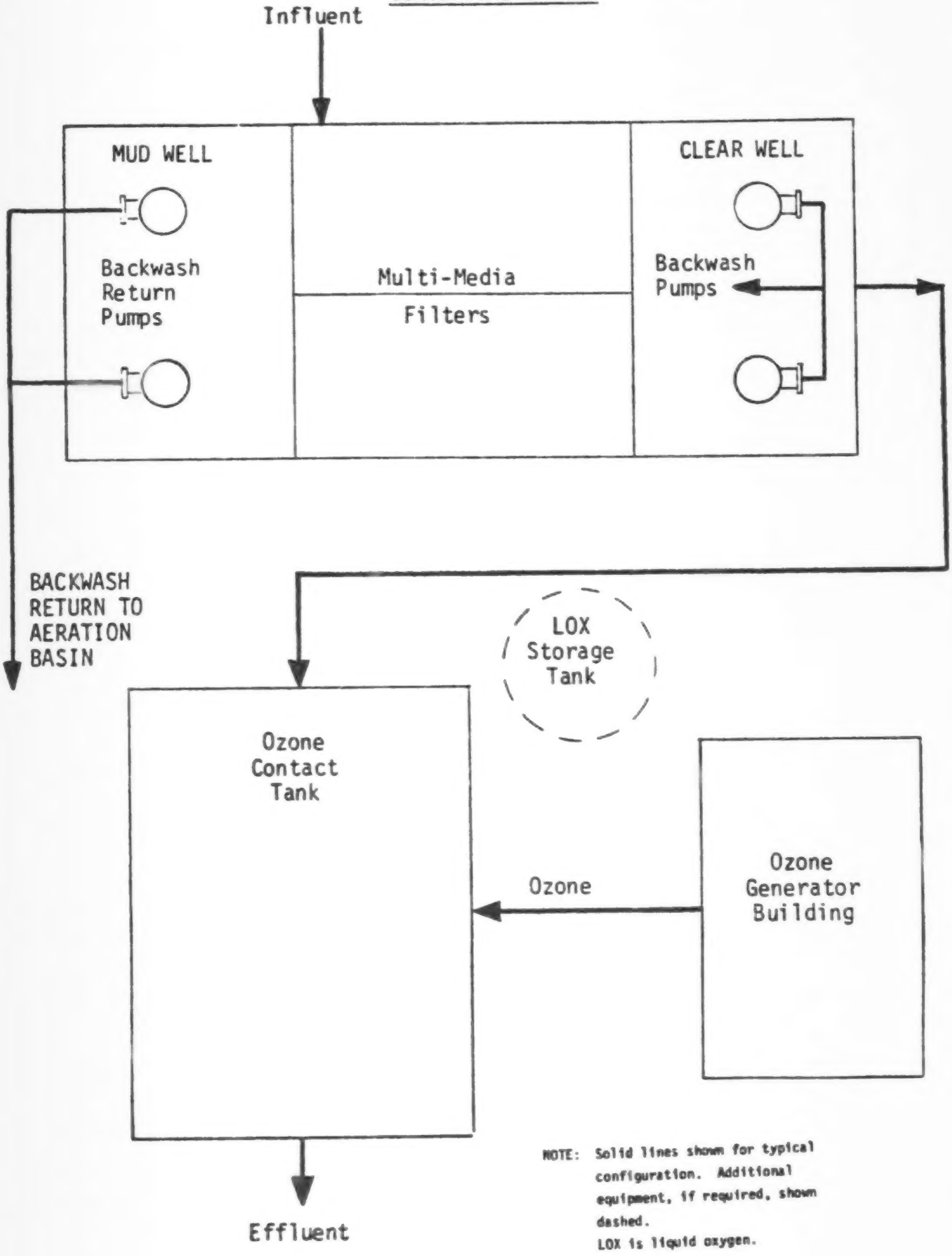

REACTOR CLARIFIER AND MULTI-MEDIA FILTRATION
CONCEPTUAL LAYOUT
Effluent
Multi Media
Filter
Backwash Return
To Aeration Basin
CHEMICAL COAGULANT
HANDLING FACILITY
REACTOR/CLARIFIER
JUNCTION
BOX
SLUDGE
PUMPS
SPLITTER
BOX
Influent
FILTRATE
SLUDGE CAKE
TO DISPOSAL
REACTOR/CLARIFIER
SLUDGE
DEWATERING
FACILITY
GRAVITY
SLUDGE
THICKENER
OVERFLOW
UNDERFLOW

FIGURE A-5

MULTI-MEDIA FILTRATION AND OZONATION CONCEPTUAL LAYOUT


Influent
MUD WELL
Backwash Return Pumps
Multi-Media Filters
CLEAR WELL
Backwash Pumps
BACKWASH RETURN TO AERATION BASIN
LOX Storage Tank
Ozone Contact Tank
Ozone
Ozone Generator Building
Effluent

NOTE: Solid lines shown for typical configuration. Additional equipment, if required, shown dashed.
LOX is liquid oxygen.

FIGURE A-6

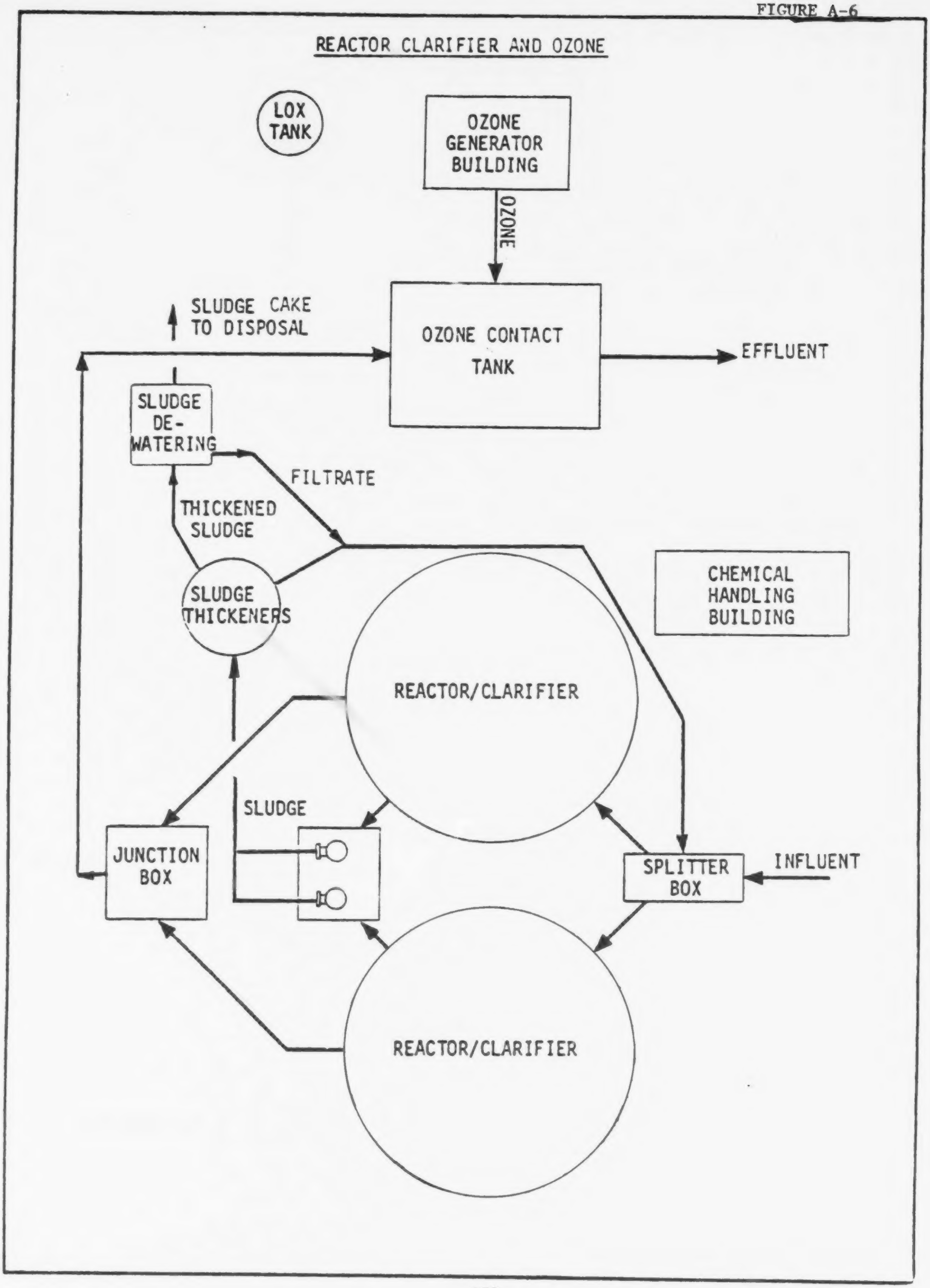

REACTOR CLARIFIER AND OZONE
LOX TANK
OZONE GENERATOR BUILDING
OZONE
SLUDGE CAKE TO DISPOSAL
OZONE CONTACT TANK
EFFLUENT
SLUDGE DE-WATERING
FILTRATE
THICKENED SLUDGE
SLUDGE THICKENERS
CHEMICAL HANDLING BUILDING
REACTOR/CLARIFIER
SLUDGE
JUNCTION BOX
SPLITTER BOX
INFLUENT
REACTOR/CLARIFIER

FIGURE A-7

REACTOR CLARIFIER AND MULTI-MEDIA FILTER AND OZONE CONCEPTUAL LAYOUT

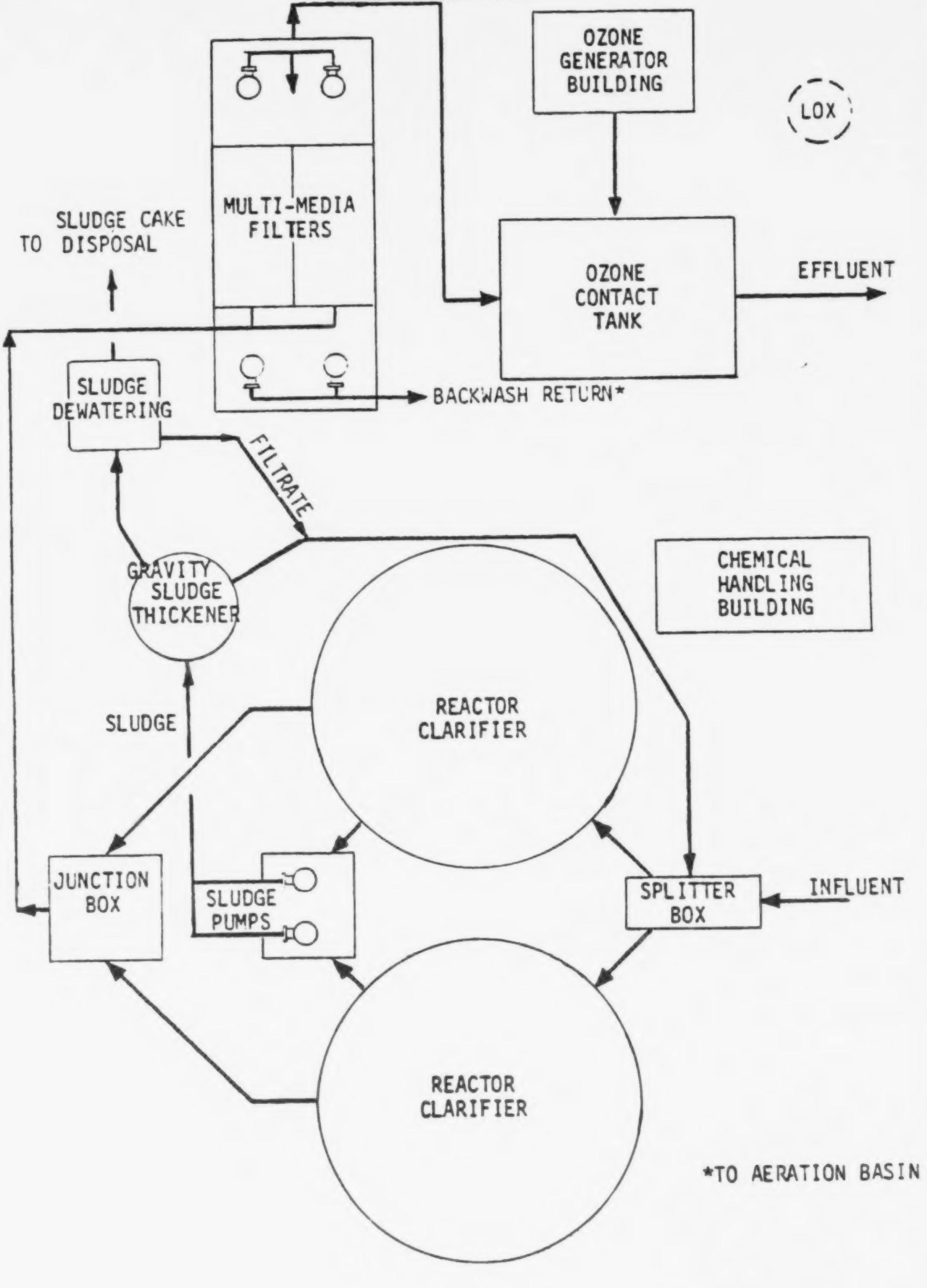

OZONE GENERATOR BUILDING
LOX
MULTI-MEDIA FILTERS
SLUDGE CAKE TO DISPOSAL
OZONE CONTACT TANK
EFFLUENT
SLUDGE DEWATERING
BACKWASH RETURN*
FILTRATE
GRAVITY SLUDGE THICKENER
CHEMICAL HANDLING BUILDING
REACTOR CLARIFIER
SLUDGE
JUNCTION BOX
SLUDGE PUMPS
SPLITTER BOX
INFLUENT
REACTOR CLARIFIER
*TO AERATION BASIN

FIGURE A-8

MULTI-MEDIA FILTER AND GRANULAR ACTIVATED CARBON ADSORPTION CONCEPTUAL LAYOUT

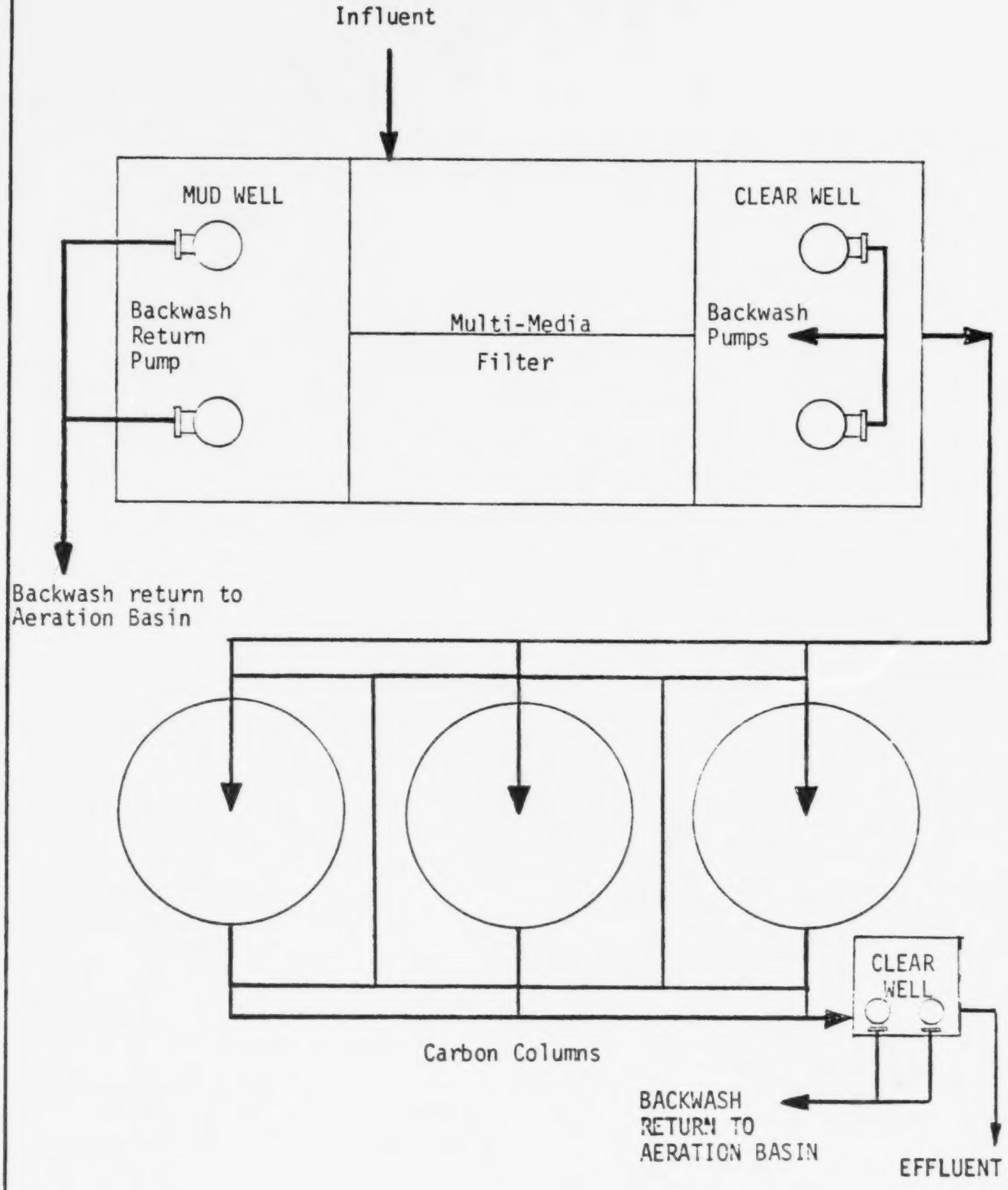
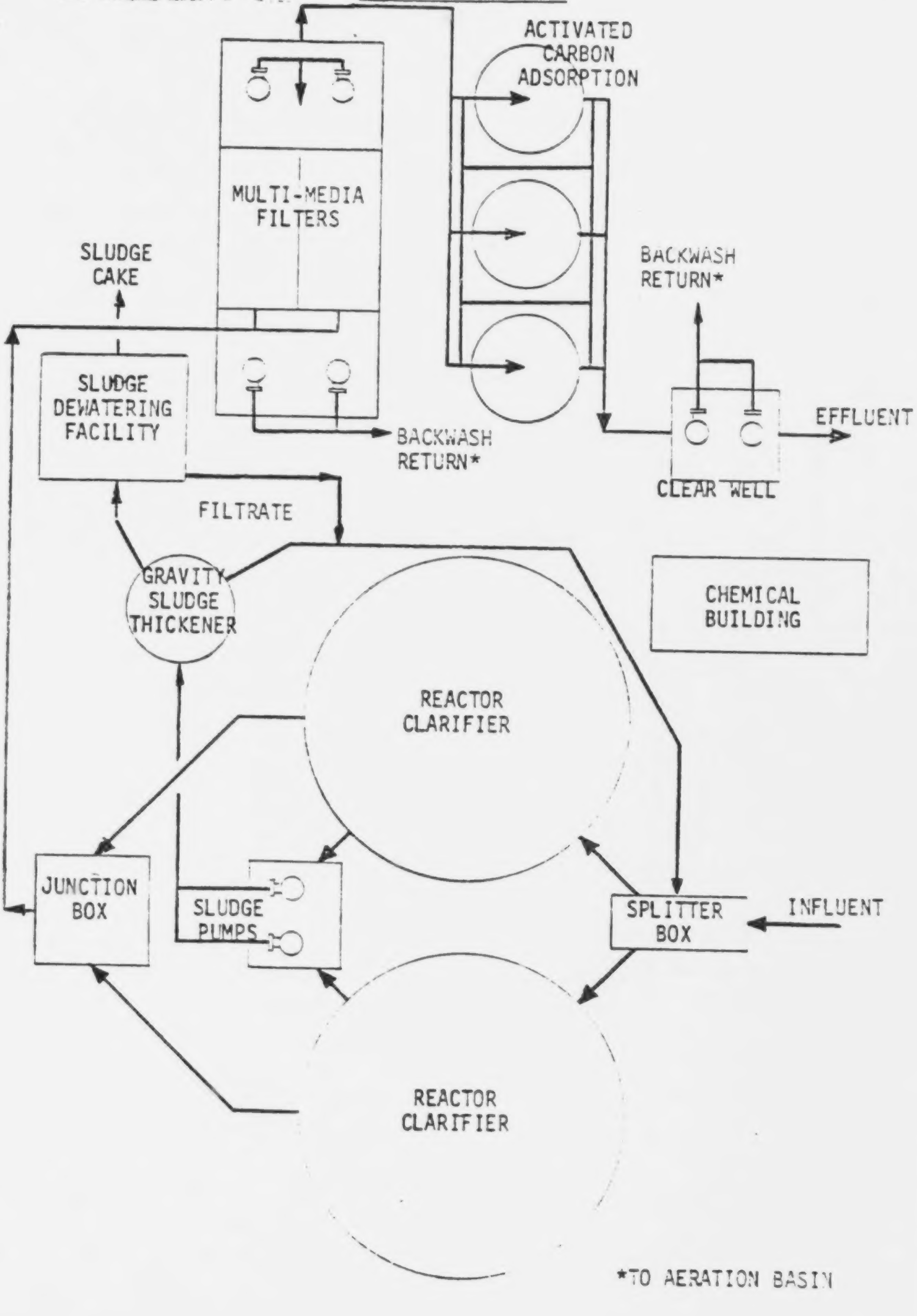

Influent
MUD WELL
Backwash
Return
Pump
Multi-Media
Filter
CLEAR WELL
Backwash
Pumps
Backwash return to
Aeration Basin
CLEAR
WELL
Carbon Columns
BACKWASH
RETURN TO
AERATION BASIN
EFFLUENT

FIGURE A-9

REACTOR CLARIFIER AND MULTI-MEDIA FILTER AND GRANULAR CARBON ADSORPTION

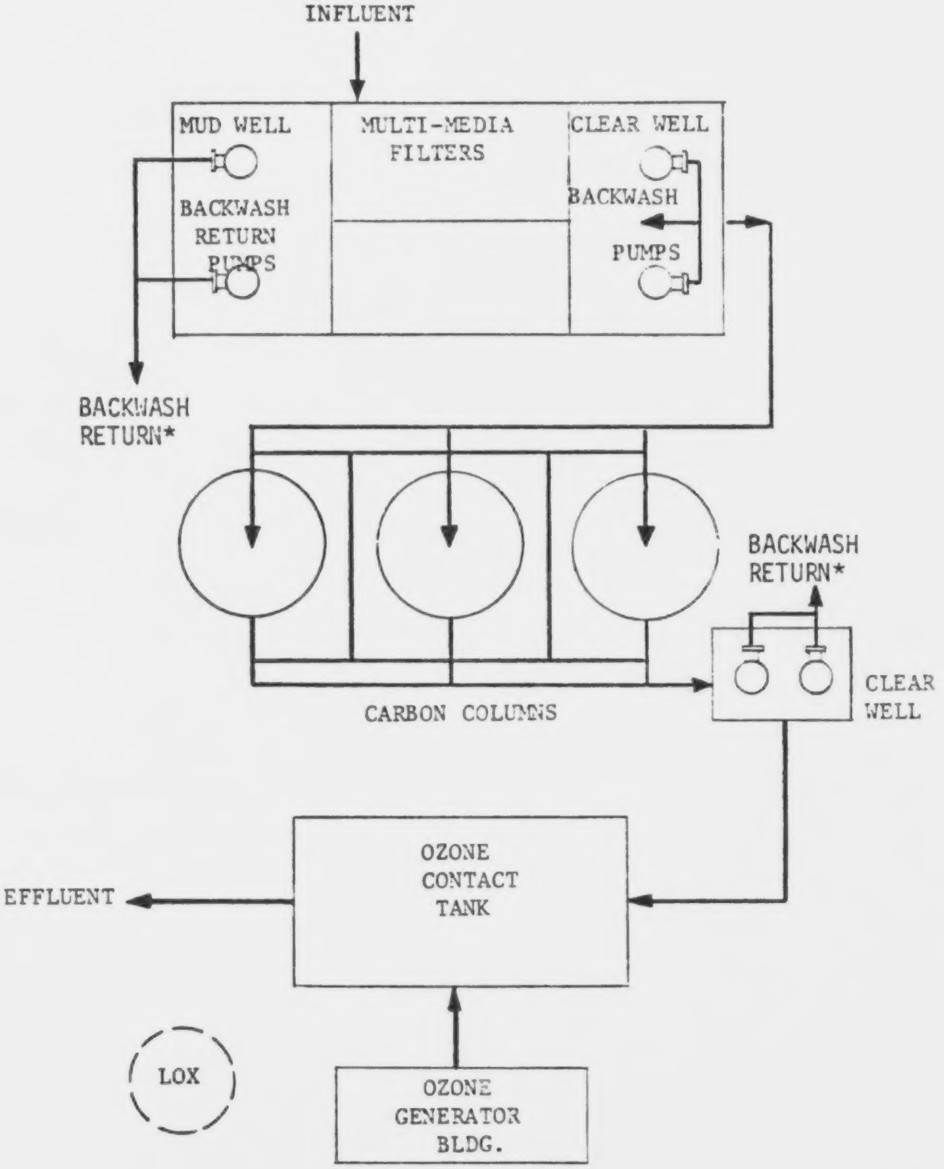
CONCEPTUAL LAYOUT


ACTIVATED CARBON ADSORPTION
MULTI-MEDIA FILTERS
SLUDGE CAKE
BACKWASH RETURN*
SLUDGE DEWATERING FACILITY
BACKWASH RETURN*
EFFLUENT
CLEAR WELL
FILTRATE
GRAVITY SLUDGE THICKENER
CHEMICAL BUILDING
REACTOR CLARIFIER
JUNCTION BOX
SLUDGE PUMPS
SPLITTER BOX
INFLUENT
REACTOR CLARIFIER

*TO AERATION BASIN

MULTI-MEDIA FILTER AND GRANULAR CARBON ADSORPTION AND OZONE

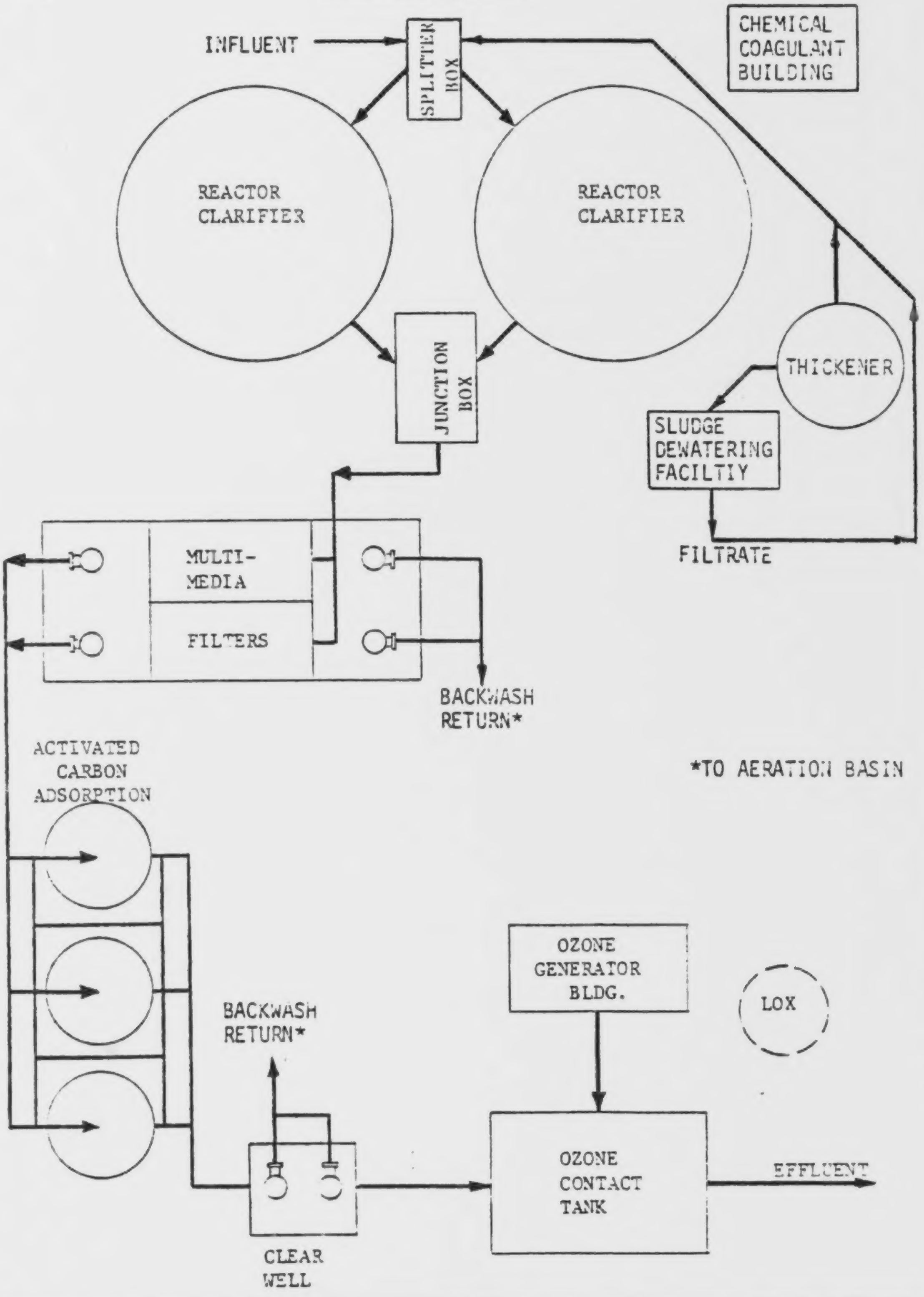
CONCEPTUAL LAYOUT


INFLUENT
MUD WELL
MULTI-MEDIA FILTERS
CLEAR WELL
BACKWASH RETURN PUMPS
BACKWASH PUMPS
BACKWASH RETURN*
BACKWASH RETURN*
CARBON COLUMNS
CLEAR WELL
OZONE CONTACT TANK
EFFLUENT
LOX
OZONE GENERATOR BLDG.

*TO AERATION BASIN

REACTOR CLARIFIER AND MULTI-MEDIA FILTER AND GRANULAR CARBON ADSORPTION AND OZONE

CONCEPTUAL LAYOUT



INFLUENT
SPLITTER BOX
CHEMICAL COAGULANT BUILDING
REACTOR CLARIFIER
REACTOR CLARIFIER
JUNCTION BOX
THICKENER
SLUDGE DEWATERING FACILTIY
FILTRATE
MULTI-MEDIA
FILTERS
BACKWASH RETURN*
ACTIVATED CARBON ADSORPTION
*TO AERATION BASIN
OZONE GENERATOR BLDG.
LOX
BACKWASH RETURN*
OZONE CONTACT TANK
EFFLUENT
CLEAR WELL

FIGURE B-1

TYPICAL LAYOUT MULTI-MEDIA FILTERS

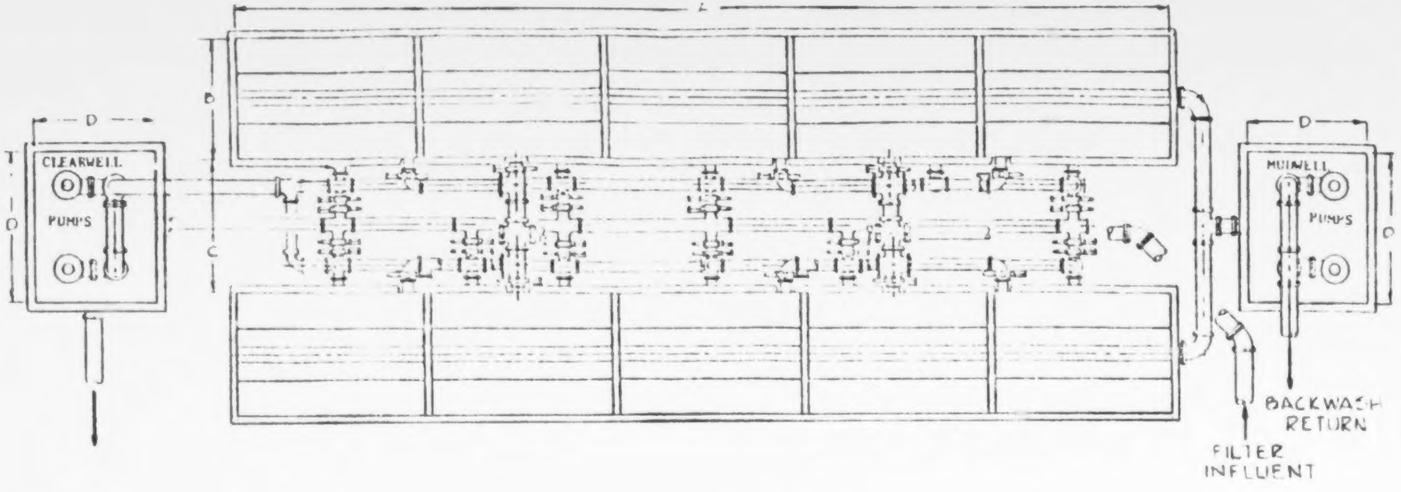
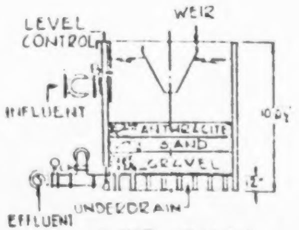

L
B
C
D
D
D
CLEARWELL
PUMPS
MUDWELL
PUMPS
BACKWASH RETURN
FILTER INFLUENT

TABLE B - TYPICAL UNIT DIMENSIONS								
No. of Cells	Cell Size	Cell Area	TOTAL FILTER AREA	A	B	C	D	APPROXIMATE UNIT OPERATIVE WEIGHT (KIPS)
2	4 X 4	16	32	8	4	-	8	98
2	6 X 6	36	72	12	6	-	16	158
2	8 X 8	64	128	16	8	-	19	242
6	4 X 6	24	144	12	6	8	6	266
6	6 X 8	48	288	18	8	8	6	482
6	10 X 8	80	480	30	8	10	8	770
6	15 X 12	180	1080	45	12	10	8	1670
6	20 X 12	240	1440	60	12	10	8	2210
10	15 X 15	225	2250	150	15	12	10	3425
10	24 X 16	384	3840	160	24	15	12	5810

TABLE A - MULTI MEDIA FILTER UNIT CONFIGURATION SELECTION		
REQUIRED SURFACE AREA SQ. FT. (A)	NO. OF FILTER CELLS	SURFACE AREA PER CELL
0 - 130	2	A/2
130 - 1500	6	A/5
1500 - 3600	10	A/8


LEVEL CONTROL
WEIR
INFLUENT
ANTHRACITE
SAND
GRAVEL
10'6"
UNDERDRAIN
EFFLUENT

FILTER SECTION

1. Surface area required ________ ft^2 (From Table 1, page 11)
2. No. filter cells ________ (From Table A)
3. Surface area per cell ________ ft^2 (From Table A)
4. Total filter area (line 2 x line 3) ________ ft^2

FIGURE B-2.1

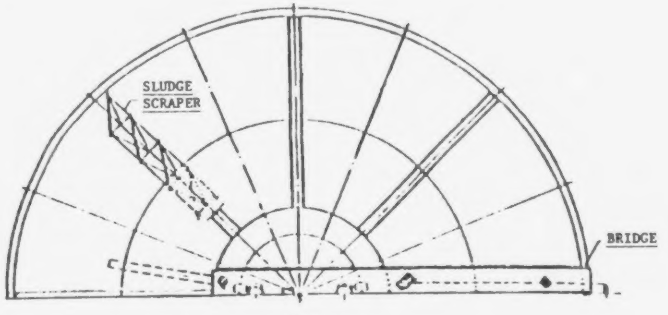
TABLE A - REACTOR CLARIFIER UNIT CONFIGURATION SELECTION			
REQUIRED SURFACE AREA (A) SQ. FT.	NO. OF UNITS	REQUIRED EFFECTIVE SURFACE AREA PER UNIT	UNIT DIAMETER RANGE
0 - 8,000	2	A/2	0 - 125
8,000 - 30,000	3	A/3	75 - 145
30,000 - 80,000	4	A/4	95 - 195

TABLE B - TYPICAL UNIT DIMENSIONS

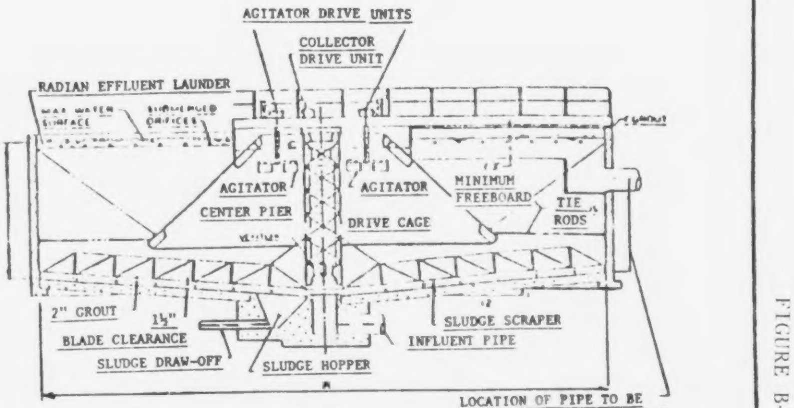
REACTOR CLARIFIER UNIT SURFACE AREAS		DIMENSIONS			APPROXIMATE OPERATING WEIGHT (KIPS)
EFFECTIVE SURFACE AREA	TOTAL SURFACE AREA	DIA. A	S.W.D. B	DIA. C	
275	319	20'	13'	7'	490
645	706	30'	14'	9'	1190
1150	1256	40'	14'	11'	2110
1800	1963	50'	14'	14'	3300
2600	2827	60'	14'	19'	4750
3500	3848	70'	15'	23'	6930
4500	5026	80'	15'	27'	9050
5500	6362	90'	15'	31'	11450
6800	7854	100'	15'	36'	14140
8200	9503	110'	15'	41' 6"	17110
9600	11309	120'	15'	47'	20360
15,000	17671	150'	15'	58'	31810
21,600	25447	180'	15'	70'	45810

1. Required surface area .... ft^2 (from Table 1, page 11)
2. Required effective surface area per unit .... ft^2 (from Table A)
3. Total surface area per unit .... ft^2 (Table B)

TYPICAL LAYOUT REACTOR CLARIFIER

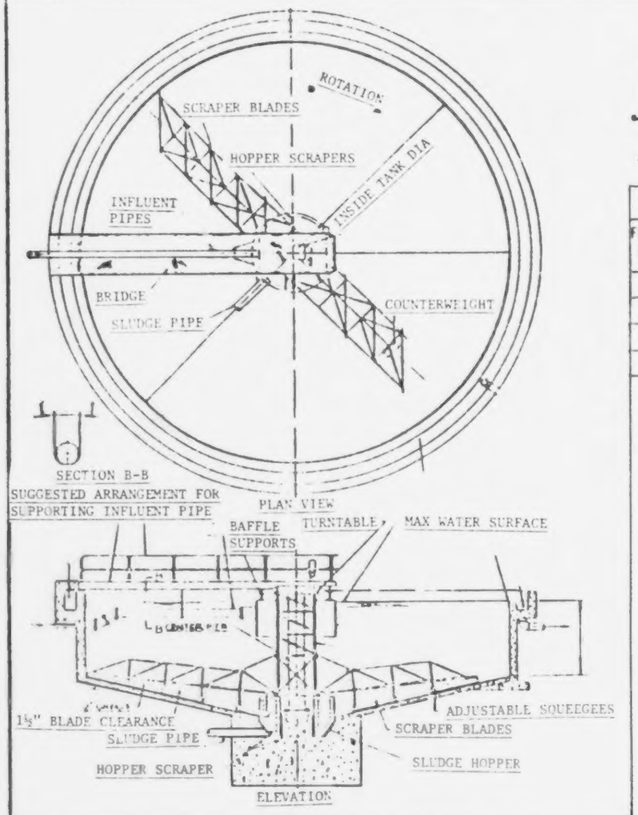

SLUDGE SCRAPER
BRIDGE
C

PLAN

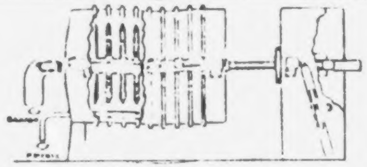

AGITATOR DRIVE UNITS
COLLECTOR DRIVE UNIT
RADIAN EFFLUENT LAUNDER
MAX WATER SURFACE
SUBMERGED ORIFICES
GROUT
AGITATOR
AGITATOR
CENTER PIER
DRIVE CAGE
MINIMUM FREEBOARD
TIE RODS
2" GROUT
1½"
BLADE CLEARANCE
SLUDGE DRAW-OFF
SLUDGE HOPPER
SLUDGE SCRAPER
INFLUENT PIPE
A
LOCATION OF PIPE TO BE DETERMINED BY APPLICATION

ELEVATION

FIGURE B-2.2


SCRAPER BLADES
ROTATION
HOPPER SCRAPERS
INSIDE TANK DIA
INFLUENT PIPES
BRIDGE
SLUDGE PIPE
COUNTERWEIGHT
SECTION B-B
SUGGESTED ARRANGEMENT FOR SUPPORTING INFLUENT PIPE
PLAN VIEW
BAFFLE SUPPORTS
TURNTABLE
MAX WATER SURFACE
1½" BLADE CLEARANCE
SLUDGE PIPE
HOPPER SCRAPER
ADJUSTABLE SQUEEGEES
SCRAPER BLADES
SLUDGE HOPPER
ELEVATION

THICKENER UNIT DIMENSIONS					
FEED RATE LBS/DAY	SOLIDS FLUX LBS/DAY/SQ.FT.	SURFACE AREA SQ FT ²	UNIT DIAMETER	S.W.D.	APPROX WT. (KIPS)
250	5	50	8	10	55
1000	5	200	16	10	220
2260	5	452	24	10	497
5090	5	1018	36	10	1120
19250	5	3848	70	10	4233



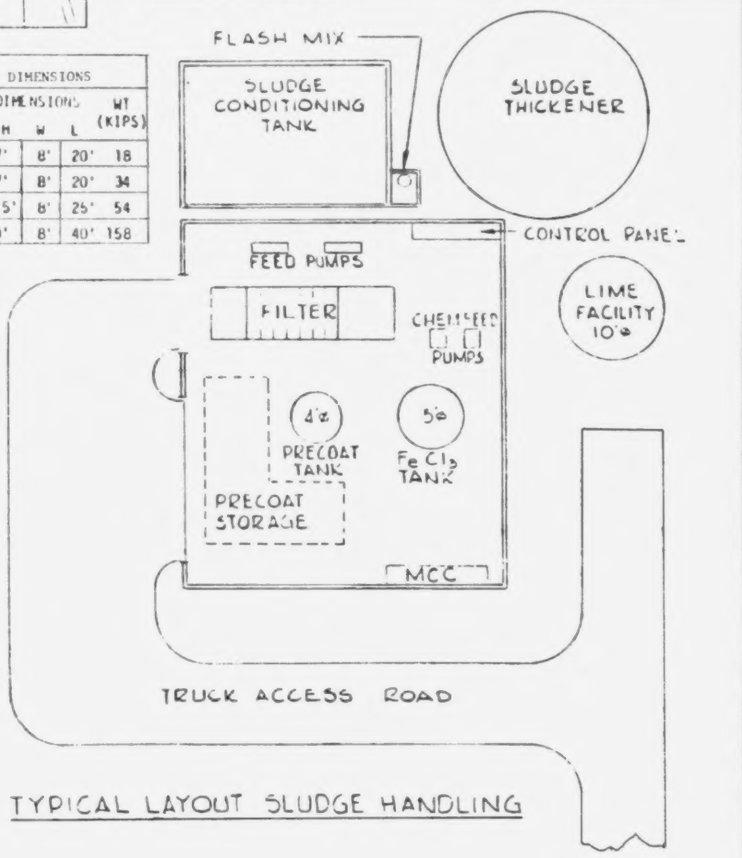
[1]PRESSURE FILTER UNIT DIMENSIONS						
FEED RATE LBS/DAY	FILTER SIZE DIA	NO. OF CHAMBERS	DIMENSIONS H	W	L	WT (KIPS)
600	52"	5	7'	8'	20'	18
2900	52"	25	7'	8'	20'	34
4700	52"	40	8.5'	8'	25'	54
20000	64"	108	10'	8'	40'	158

[1] Filter size based on 8-hour per day/7 days per week operation.

[2] To calculate thickener surface area:

$$\frac{\text{Feed rate lb/day}}{5\ \text{lb/day/ft}^2} = \frac{\_\_\_\_\_\_\ \text{lb/day}}{5\ \text{lb/day/ft}^2} = \_\_\_\_\_\_\_\_\_\ \text{ft}^2$$

UNIT CONFIGURATION SELECTION THICKENER OR FILTER		
FEED RATE LBS/DAY	NUMBER OF UNITS	RANGE OF UNIT SIZE LBS/DAY
300 - 30,000	1	300 - 30,000


FLASH MIX
SLUDGE CONDITIONING TANK
SLUDGE THICKENER
CONTROL PANEL
FEED PUMPS
FILTER
CHEM FEED PUMPS
LIME FACILITY 10'ø
4'ø PRECOAT TANK
5'ø Fe Cl3 TANK
PRECOAT STORAGE
MCC
TRUCK ACCESS ROAD

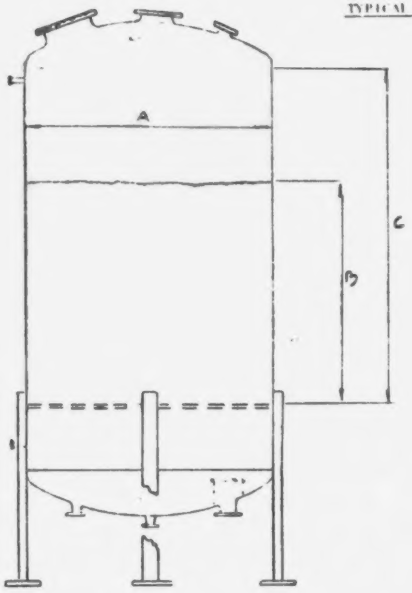
TYPICAL LAYOUT SLUDGE HANDLING

FIGURE B-3

TABLE A - ACTIVATED GRANULAR CARBON ADSORPTION UNIT CONFIGURATION SELECTION		
CARBON BED VOLUME (V) CU. FT.	NO. OF UNITS	BED VOLUME PER UNIT
0 - 1800	3	V/2
1800 - 3600	4	V/3
3600 - 4500	5	V/4
4500 - 10000	6	V/5
10000 - 54000	12	V/11

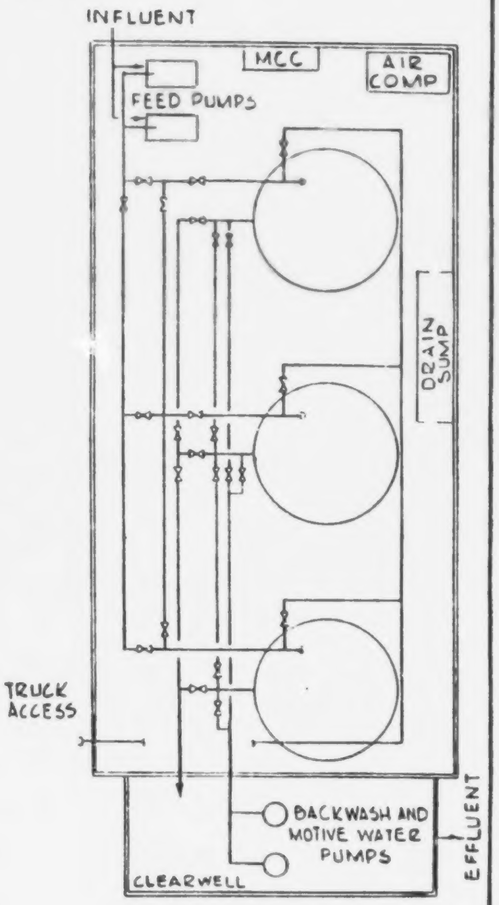
TABLE B - TYPICAL UNIT DIMENSIONS

BED VOLUME CU. FT.	A	B	C	UNIT OPERATIVE WEIGHT (KIPS)
200	5.6	8	12	33
900	12	8	12	149
1800	17	8	12	297
2700	20.7	8	12	446



TYPICAL VESSEL ELEVATION

TYPICAL LAYOUT CARBON ADSORPTION


INFLUENT
MCC
AIR COMP
FEED PUMPS
DRAIN SUMP
TRUCK ACCESS
BACKWASH AND MOTIVE WATER PUMPS
CLEARWELL
EFFLUENT

1. Required total carbon bed volume _______ ft^3 (From Table 1, page 11)
2. Carbon bed volume per unit = ________ ft^3 (From Table A)
3. Number of units _______. (From Table A)

FIGURE B-4

TABLE A - OZONATION UNIT CONFIGURATION SELECTION

OZONE FEED LB/DAY	NO. OF UNITS	UNIT SIZE LB/DAY/UNIT	TYPE SYSTEM
0 - 500	1	0-500	AIR
500 - 1000	2	0-500	AIR
1000 - 1500	1	600-1500	OXYGEN/ RECYCLE
1500 - 4000	2	500-4000	"

OZONE GENERATOR

OZONE LB/DAY	DIMENSIONS			WEIGHT (LBS)	FLOW SCFM	
	H	L	D			
35	7'	4½'	8'	1500	16	AIR
42	7'	4½'	8'	3800	20	
50	7'	5'	9'	4000	23	
70	8'	6'	10'	5000	33	
100	8'	6'	10'	6500	47	
150	6'	7'	8'	6500	70	
250	6'	7'	12'	10000	116	
400	6'	8'	19'	16000	186	
700	6'	8'	26'	25000	326	
520	6'	7'	10'	8000	93	OXYGEN
650	6'	7'	12'	10000	116	
780	6'	8'	12'	12000	140	
1040	6'	8'	19'	16000	186	
1300	6'	8'	22'	19000	233	
1560	6'	8'	24'	22000	280	
2000	6'	8'	28'	28000	360	

AIR PREPARATION UNIT

AIR FLOW SCFM	DIMENSIONS			WEIGHT (LBS)
	H	W	D	
60	8'	4'	5'	3300
75	7'	5'	6½'	3800
100	9'	6'	7'	4500
125	9'	6'	7'	4500
150	8½'	6'	7½'	5000
200	10½'	6'	7½'	5000
250	10'	6'	8'	5000
300	10'	7'	8'	7200
350	10'	7'	8'	7400
700	11'	8'	12'	12000

OZONE CONTACTOR

PLANT FLOW MGD	CU. FT. REQ'D	A	B	APPROX. WEIGHT (KIPS)
0.5	1390	10'	20'	224
1	2780	12'	33'	448
3	9350	20'	60'	1344
5	13930	25'	80'	2240
7	19500	30'	90'	3024
10	27850	40'	100'	4480

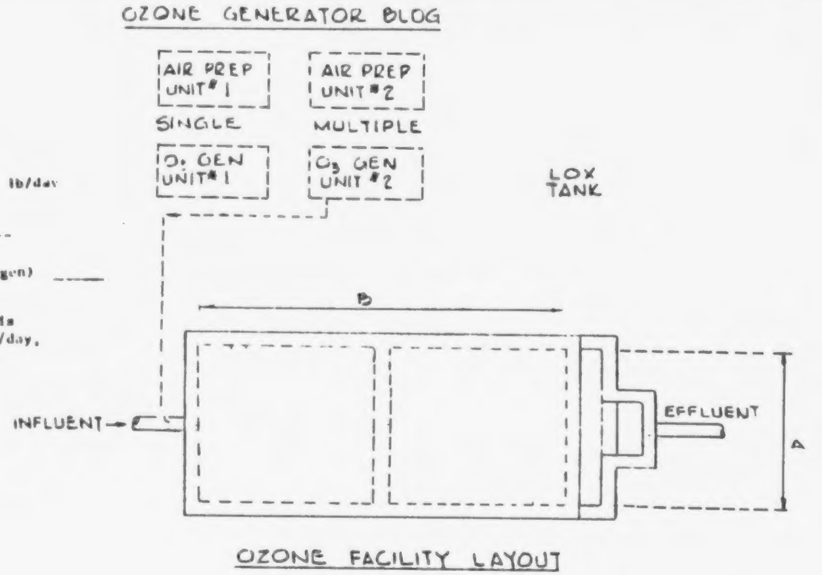
OXYGEN SUPPLY

TANK SIZE	DIA	H	APPROX. WEIGHT FULL
40 TON	11'	29'	103 KIPS

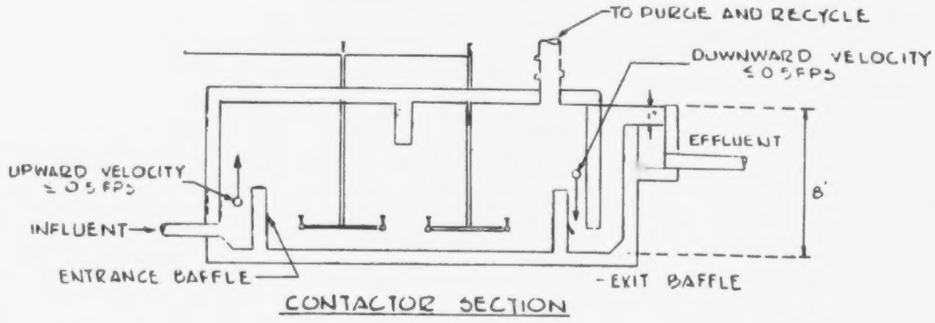
TYPICAL LAYOUT OZONE

1. Required ozone _______ lb/day
(From Table 1, page 11)
2. Number of units _______
(From Table A)
3. Type system (air or oxygen) _______
(From Table A)

NOTE: If ozone requirement is greater than 4000 lbs/day, use additional units.


OZONE GENERATOR BLDG
AIR PREP UNIT#1
AIR PREP UNIT#2
SINGLE
MULTIPLE
O3 GEN UNIT#1
O3 GEN UNIT #2
LOX TANK
B
INFLUENT
EFFLUENT
A

OZONE FACILITY LAYOUT


TO PURGE AND RECYCLE
DOWNWARD VELOCITY ≤ 0.5 FPS
EFFLUENT
B'
UPWARD VELOCITY ≤ 0.5 FPS
INFLUENT
ENTRANCE BAFFLE
EXIT BAFFLE

CONTACTOR SECTION

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FIGURE B-5

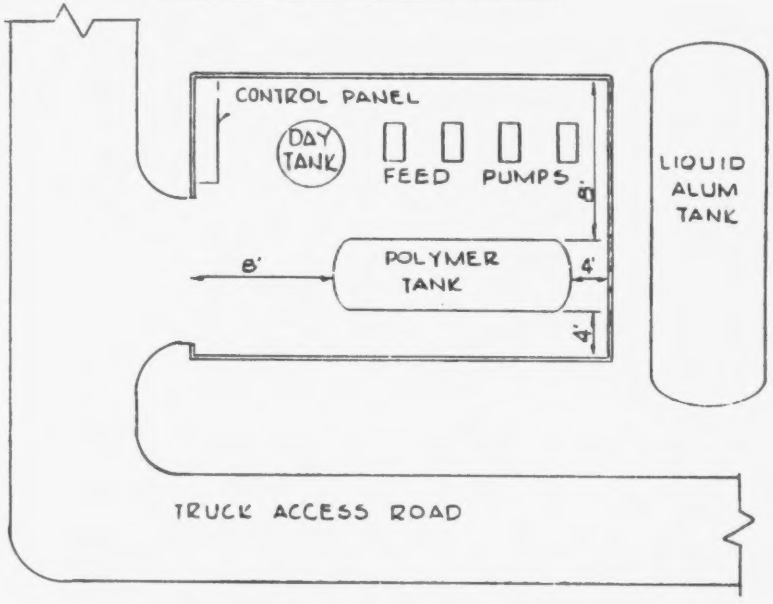
TABLE A - CHEMICAL HANDLING FACILITIES

UNIT CONFIGURATION SELECTION

FEED RATE GALLONS/DAY	NO. OF TANKS	TANK SIZE GALLONS	
0 - 500	1	5000	ALUM *
500 - 1000	1	10000	
1000 - 2000	1	20000	
2000 - 4000	2	20000	
0 - 150	1	100	POLYMER
150 - 500	1	500	
500 - 1000	1	1000	
1000 - 2000	1	2000	
2000 - 5000	1	5000	
5000 - 10,000	1	10000	

TYPICAL TANK DIMENSIONS

CAPACITY GALLONS	DIA. FEET	LENGTH FEET	APPROX FULL WEIGHT (KIPS)
100	2	5	1
500	4	7	5
1000	5	8	10
5000	10	10	50
10000	12	12	100
20000	12	24	200


CONTROL PANEL
DAY TANK
FEED PUMPS
8'
POLYMER TANK
8'
4'
4'
LIQUID ALUM TANK
TRUCK ACCESS ROAD

TYPICAL LAYOUT CHEMICAL HANDLING BLDG.

1. Alum feed rate lb/day ______. (From Table 1, page 11)
2. Alum tank size ______ gallons (From Table A)
3. Polymer feed rate lb/day ______ (From Table 1, page 11)
4. Polymer tank size ______ gallons (From Table A)

PART II

CAPITAL COST ESTIMATE

PART II

CAPITAL COST ESTIMATE

After establishing the equipment selection and size in Part I a capital cost can be estimated. The procedure for developing the capital cost is based on determining installed cost for major equipment from cost curves and estimating other construction costs from the guidelines provided to account for site specific factors. A detailed site specific layout of the AWT system is required as part of this task. Figure C-0.0 should be used to summarize your AWT capital cost estimate. Other supplimental information should also be provided to support your estimate.

Figures C-1 through C-5 are installed major equipment cost curves. The costs represented by these curves include such items as initial charge of carbon or media, tankage, prime movers, structural, drive mechanism, buildings and normal foundations (assuming minimum 2500 psf allowable bearing capacity). Form C-0.0 is organized such that the major equipment costs obtained from Figures C-1 through C-5 may be compiled on the appropriate lines 1 through 5. These equipment costs may then be summed to arrive at a total major equipment cost. Lines 8 through 22 are for additional cost items which are more site specific.

In order to determine a cost for major piping (line 10 of Figure C-0.0) a detailed site specific layout should be made to scale using the equipment you have selected in Part I. After completion of this layout, lengths of major piping may be scaled and appropriate unit costs from a recognized and current estimating guide such as the "1979 Dodge Manual" should be applied. The cost for major piping should be entered on line 10 of Figure C-0.0. The cost for special foundations or dewatering (if necessary for specific site application) should be entered on line 15A. If additional pumping is identified from the layout, this should be included as part of items 8 through 15.

Knowledge of specific site conditions, including soils data, topography, local economy and labor markets, availability of power and equipment, area constraints as well as engineering judgement should be used to determine construction cost items. The following is an outline indicating specific items and cost considerations which may be included as part of the additional construction cost items as listed on lines 8 through 15A of the estimate preparation form. Percentages are indicated on the form as a general guide. After determing dollar values for the additional construction cost items, calculate the percentage you have used for checking purposes.

Line No. (From Figure C-0.0)

8 Minor Mechanical Equipment

- 8.1 Items included
  - 8.1.1 Chemical feed pumps
  - 8.1.2 Air compressors
  - 8.1.3 Sump pumps
  - 8.1.4 Sludge pumps (P.D.)
  - 8.1.5 Vehicles (sludge, carbon, etc.)
  - 8.1.6 Loading dock equipment (bumpers ramps, etc.)
  - 8.1.7 Cranes
  - 8.1.8 Slide gates and operators
  - 8.1.9 Office and laboratory equipment and furniture
  - 8.1.10 Mixers
  - 8.1.11 Conveyors
  - 8.1.12 Meters and gages
  - 8.1.13 Plumbing (drains fixtures, hot water heaters, eye wash, showers, etc.)
  - 8.1.14 Fire protection (sprinklers, extinguishers, alarms, etc.)
  - 8.1.15 Heat generation
  - 8.1.16 Fuel handling and storage facilities
  - 8.1.17 Air conditioning and ventilation
- 8.2 Factors affecting costs
  - 8.2.1 Corrosiveness and temperature of fluids pumped
  - 8.2.2 Solids content and characteristics of fluids
  - 8.2.3 Availability of existing equipment
  - 8.2.4 Climate
  - 8.2.5 Specific site layout
  - 8.2.6 Local building and fire codes
  - 8.2.7 Local availability of equipment
  - 8.2.8 Type of existing uitilities (gas, electric, oil)

9 Electrical

- 9.1 Items included
  - 9.1.1 Standby power generation/transmission
  - 9.1.2 Power transmission
  - 9.1.3 Motor and unit control centers
  - 9.1.4 Lighting
  - 9.1.5 Controls and switches
  - 9.1.6 Motors
- 9.2 Factors affecting cost
  - 9.2.1 Availability and location of existing power supplies
  - 9.2.2 Proportion of power intensive equipment
  - 9.2.3 Local electrical codes
  - 9.2.4 Local zoning (overhead vs. underground transmission)

10 Major Piping

- 10.1 Items included
  - 10.1.1 Valves and vaults (manual)
  - 10.1.2 Valves and vaults (automatic)
  - 10.1.3 Steel pipe, welding, fittings, etc.
  - 10.1.4 Ductile iron pipe, fittings, etc.
  - 10.1.5 Fiberglas pipe
  - 10.1.6 Drainage pipe (concrete corrugated, etc.)
  - 10.1.7 Other pipe
  - 10.1.8 Pipe supports, thrust flocks, etc.
  - 10.1.9 Hydrants
  - 10.1.10 Trenching
  - 10.1.11 R/W or easements
  - 10.1.12 Heat tracing
- 10.2 Factors affecting cost
  - 10.2.1 Corrosive properties of fluids and soils
  - 10.2.2 Underground vs. exposed piping
  - 10.2.3 Climatologic conditions
  - 10.2.4 Site drainage
  - 10.2.5 Soils data

        - 10.2.6 Process layout
        - 10.2.7 Flows, pipe sizes
        - 10.2.8 Power costs
        - 10.2.9 Property size, shape, etc.

10A Minor Piping

- 10.1 Items included
    - 10.1.1 Valves - manual
    - 10.1.2 Valves - automatic
    - 10.1.3 Black and glavanized steel pipe
    - 10.1.4 Copper tubing
    - 10.1.5 Fittings
    - 10.1.6 Stainless steel pipe
    - 10.1.7 Other pipe
    - 10.1.8 Pipe supports flashing seals, etc.
    - 10.1.9 Heat Tracing
    - 10.1.10 Hydrants
    - 10.1.11 Trenching
- 10.2 Factors affecting cost
    - 10.2.1 Corrosive properties of fluid
    - 10.2.2 Underground vs. exposed piping
    - 10.2.3 Unit configurations
    - 10.2.4 Flows, pipe size

11 Miscellaneous Metals

- 11.1 Items included
    - 11.1.1 Grating
    - 11.1.2 Pipe racks
    - 11.1.3 Equipment supports
    - 11.1.4 Hand railings
    - 11.1.5 Fencing
    - 11.1.6 Ladders
    - 11.1.7 Manhole and access frames and covers
- 11.2 Factors influencing costs
    - 11.2.1 Local labor and steel markets
    - 11.2.2 Equipment selection and configuration
    - 11.2.3 Existing facilities
    - 11.2.4 Building codes

12 Miscellaneous Concrete

- 12.1 Items included
  - 12.1.1 Concrete supports
  - 12.1.2 Manholes and drainage inlets
  - 12.1.3 Stairs and entrances
  - 12.1.4 Curbs and gutters
  - 12.1.5 Loading docks
- 12.2 Factors influencing costs
  - 12.2.1 Local labor and concrete markets
  - 12.2.2 Plant configuration
  - 12.2.3 Existing facilities
  - 12.2.4 Building codes
  - 12.2.5 Aesthetic considerations

13 Instrumentation

- 13.1 Items included
  - 13.1.1 Monitoring devices
  - 13.1.2 Equipment controls
  - 13.1.3 Graphic panels alarms and signal transmission
  - 13.1.4 Control building
- 13.2 Factors influencing costs
  - 13.2.1 System complexity
  - 13.2.2 Existing hardware

14 Painting and Protective Coatings

- 14.1 Items included
  - 14.1.1 Paint
  - 14.1.2 Epoxy
  - 14.1.3 Creosote
- 14.2 Factors influencing costs
  - 14.2.1 Aesthetics
  - 14.2.2 Environmental corrosiveness (air, fluids and soil)

15 Site Work and Erosion Control

15.1 Items included

15.1.1 Earthwork
15.1.2 Grading rough and final
15.1.3 Vegetative stabilitzation
15.1.4 Erosion and sediment control
15.1.5 Paving - access road, parking, loading, etc.
15.1.6 Real estate

15.2 Items influencing costs

15.2.1 Topography
15.2.2 Local building codes and permit requirements
15.2.3 Soil conditions
15.2.4 Available land/zoning

15A Special Foundations/Dewatering, etc.

15A.1 Items included

15A.1.1 Piling
15A.1.2 Spread foundations
15A.1.3 Dewatering (well points, etc.)
15A.1.4 Miscellaneous other design and construction considerations

15A.2 Factors affecting costs

15A.2.1 Soils data
15A.2.2 Previous experience

Additional capital cost items (lines 17 through 21) should be completed based on your company experience with similar construction projects. Again a percentage range (percent of sum of lines 7 and 16) has been provided as a guide. The total percentage add-on is entered on line 22.

Additional capital cost associated with your secondary treatment facility to treat backwash flow from the multi-media filter and/or carbon adsorbers should be entered on line 23. If you did not have either a multi-media filter or carbon adsorber in your AWT system, then leave this space blank. If you do have backwash flow to treat then prorate the present worth capital cost of your secondary facility by the ratio of backwash flow to average flow to obtain this estimated cost.

Calculate the total capital cost by the formula presented on line 24 of Figure C-0.0.

As an example in development of the capital cost estimate, the multi-media filter sized in Part I will be examined. The total filter area of 480 square feet is entered on the x-axis of Figure C-1. The corresponding value of $168,000 is read from the y-axis. This represents the major equipment installed cost for multi-media filters, and is entered on line 1 of form C-0.0. Other units included in the AWT system you have selected should be similarly estimated and entered on the appropriate line of Figure C-0.0. A detailed site specific layout should be developed for your AWT system. Minor equipment and construction cost items and capital cost items should now be estimated and values entered on the appropriate lines of Figure C-0.0. After completing all items on the form which apply to your AWT system a capital cost may be determined using the formula given on line 24.

FIGURE C-0.0

CAPITAL COST ESTIMATE PREPARATION FORM

MAJOR EQUIPMENT COSTS (FROM FIGURES C-1 - C-5)		DOLLARS
1.	MULTI-MEDIA FILTER	
2.	REACTOR CLARIFIER	
2A.	SLUDGE HANDLING Thickener ( ) + Pressure Filter ( ) =	
3.	CARBON ADSORPTION	
4.	OZONE GENERATOR ( ) + CONTACTOR ( ) =	
5.	CHEMICAL HANDLING ALUM ( ) + POLYMER ( ) +	
7.	TOTAL MAJOR EQUIPMENT COST (SUM ITEMS 1-5)	

ADDITIONAL CONSTRUCTION COST ITEMS *		PERCENTAGE (of Line 7)		DOLLARS
ITEM		% RANGE	% USED	
8.	MINOR MECHANICAL EQUIPMENT	5-50		
9.	ELECTRICAL	10-25		
10.	MAJOR PIPING		☒	
10A.	MINOR PIPING	20-60		
11.	MISCELLANEOUS METALS	5-10		
12.	MISCELLANEOUS CONCRETE	5-20		
13.	INSTRUMENTATION	5-15		
14.	PAINTING & PROTECTIVE COATINGS	3-10		
15.	SITE WORK & EROSION CONTROL	5-15		
15A.	SPECIAL FOUNDATIONS/DEWATERING, ETC.		☒	
16.	CONSTRUCTION COST ITEMS (SUM LINES 8 THRU 15A)			
16A.	TOTAL CONSTRUCTION COST (SUM LINES 7 AND 16)			

ADDITIONAL CAPITAL COST ITEMS

ITEM		% RANGE	% USED
17.	CONTRACTOR OVERHEAD AND PROFIT	10-25	
18.	ENGINEERING	10-20	
19.	LEGAL AND ADMINISTRATIVE	2-5	
21.	CONTINGENCIES	15-25	

22. "ADD-ON" PERCENTAGE (SUM ITEMS 17-21) ☐

23. COST OF TREATING ADDITIONAL FLOW IN EXISTING BPT FACILITY = ** ☐

24. $\text{CAPITAL COST} = (\text{LINE 16} \quad \times (1 + \frac{\text{LINE 22}}{100}) + (\text{LINE 23})$

$\text{CAPITAL COST} = (\_\_\_\_\_\_ \quad (1 + \frac{\_\_\_\_\_\_}{100}) + (\_\_\_\_\_\_) =$ ☐

*Submit supporting information for items 8 through 15A with final cost estimate

NOTE: ALL costs are based on January 1979 dollars.

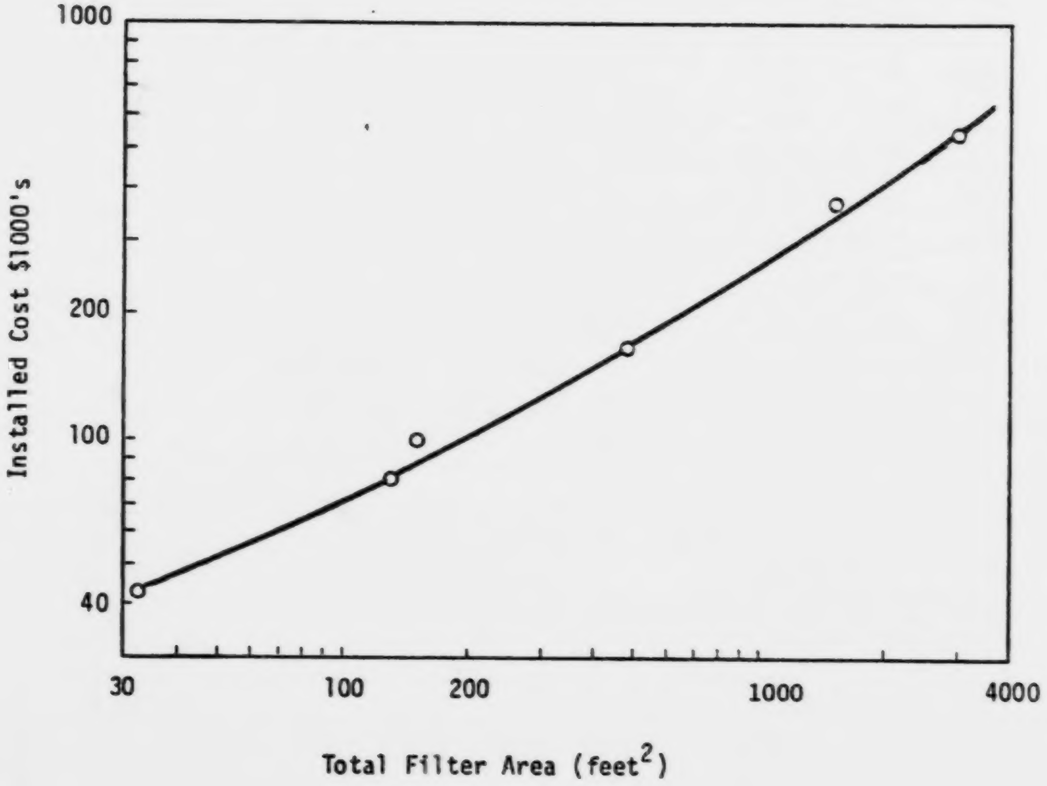
** For calculation, See Page II-17.

MULTI-MEDIA FILTERS

MAJOR EQUIPMENT INSTALLED COST

Installed cost includes normal foundations - mud & clear wells - b.w. pumps and b.w. return pumps.

Does not include piping-electrical-contr. OH&P-engineering-painting-misc. metal & concrete-instrumentation, etc.



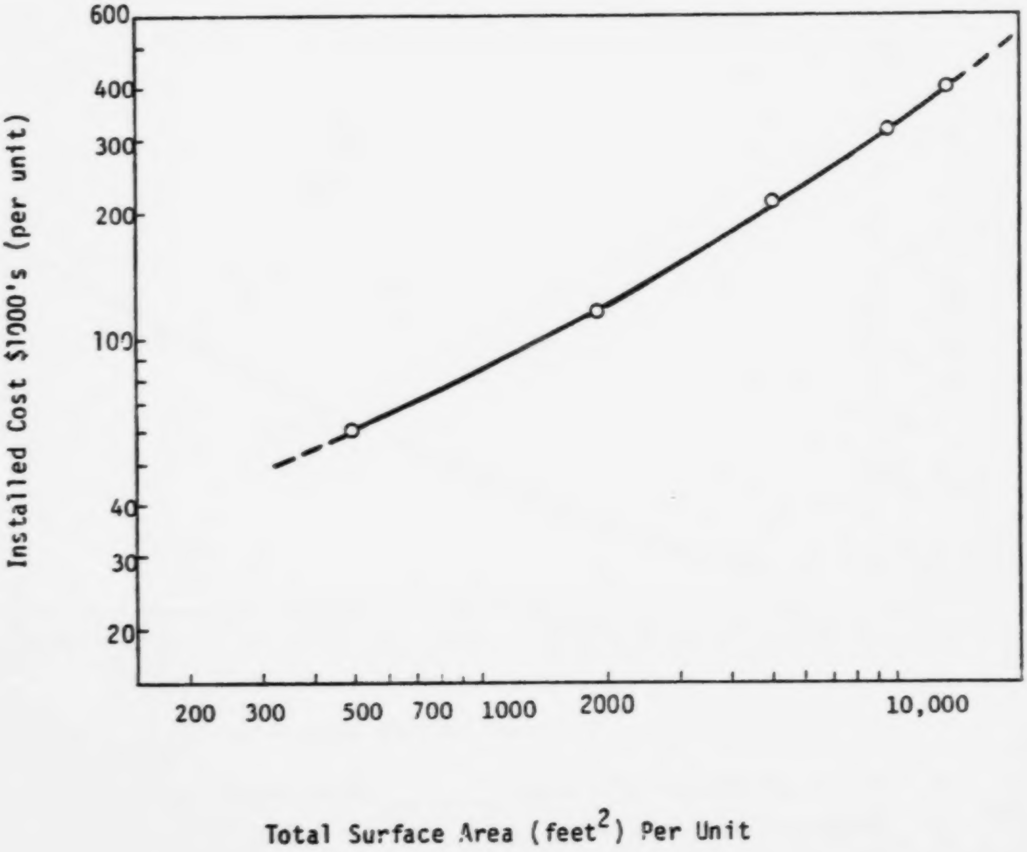
1. Total Filter Area ________ ft^2 (From Figure B-1)
2. Installed Cost $________

REACTOR CLARIFIER

MAJOR EQUIPMENT INSTALLED COST

Installed cost includes normal foundations, drives, rakes, tankage, shop primer paint and installation for above ground steel tank application.

Not included is sludge handling, chemical feed, piping, electrical, contr. OH&P, engineering, painting, misc. metal and concrete, instrumentation, etc.



1. Total surface area per unit ______ ft² (From Fig. B-2.1, line 3)
2. Installed cost per unit $__________
3. Number of units ________. (From Table A, Fig. B-2.1)
4. Total installed cost $__________. (line 2 x line 3)

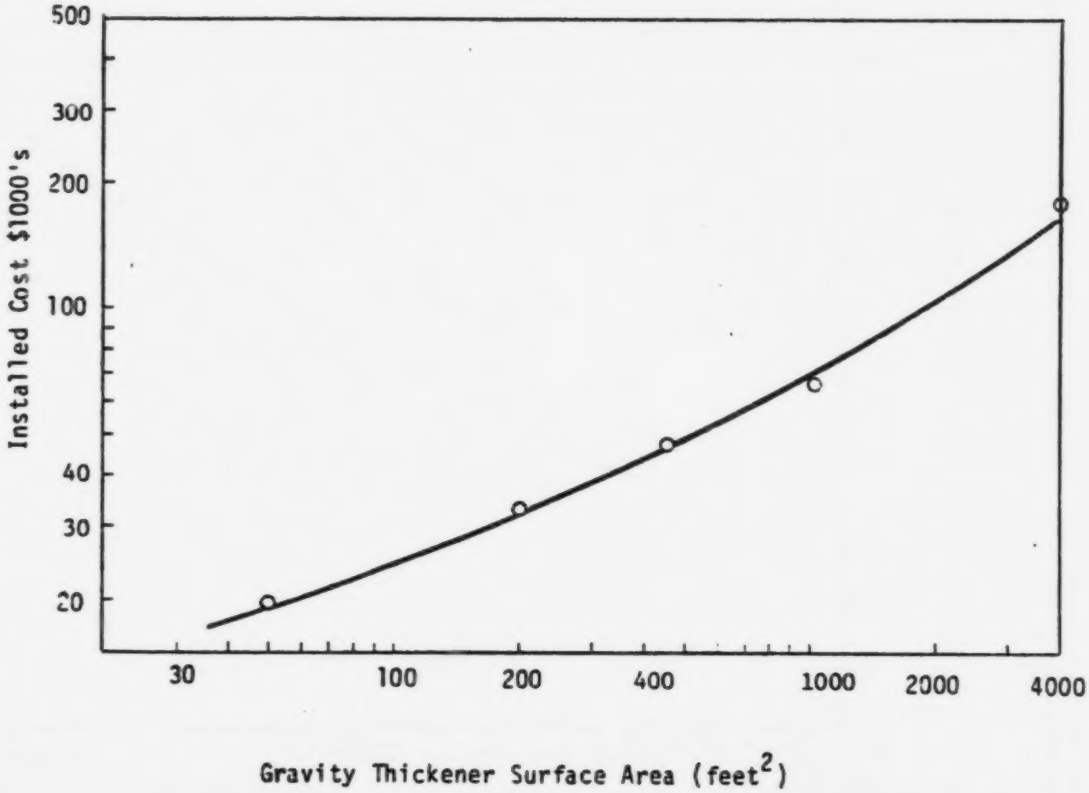
FIGURE C-2.2

SLUDGE GRAVITY THICKENING

MAJOR EQUIPMENT INSTALLED COST

Cost includes normal foundations, drives, rakes, tankage, primer paint and installation.

Not included is chemical feed, piping, electrical, contr. OH&P, engineering, painting, etc.



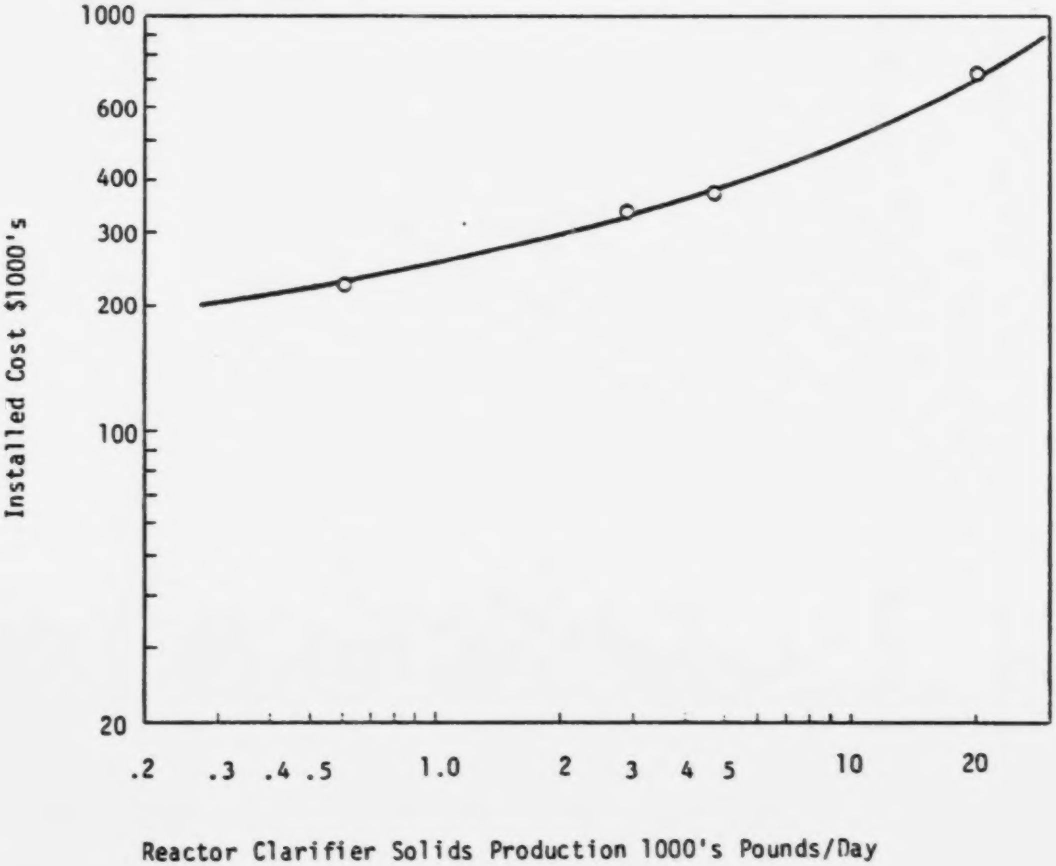
1. **Solids production (lbs/day) ________ (From Table 1, page ii)**
2. **Thickener surface area _________ ft² (From Fig. B-2.2)**
3. **Installed cost $_________.**

SLUDGE DEWATERING (Pressure Filter)

MAJOR EQUIPMENT INSTALLED COST

Cost includes equipment, building, normal foundation, chemical feed equipment (lime and precoat), feed pumps and installation.

Not included is piping, electrical, mechanical, contr. OH&P, engineering, protective coatings, etc.



1. Solids production (lbs/day) ________ (From Table 1, page ii)
2. Installed cost $____________.

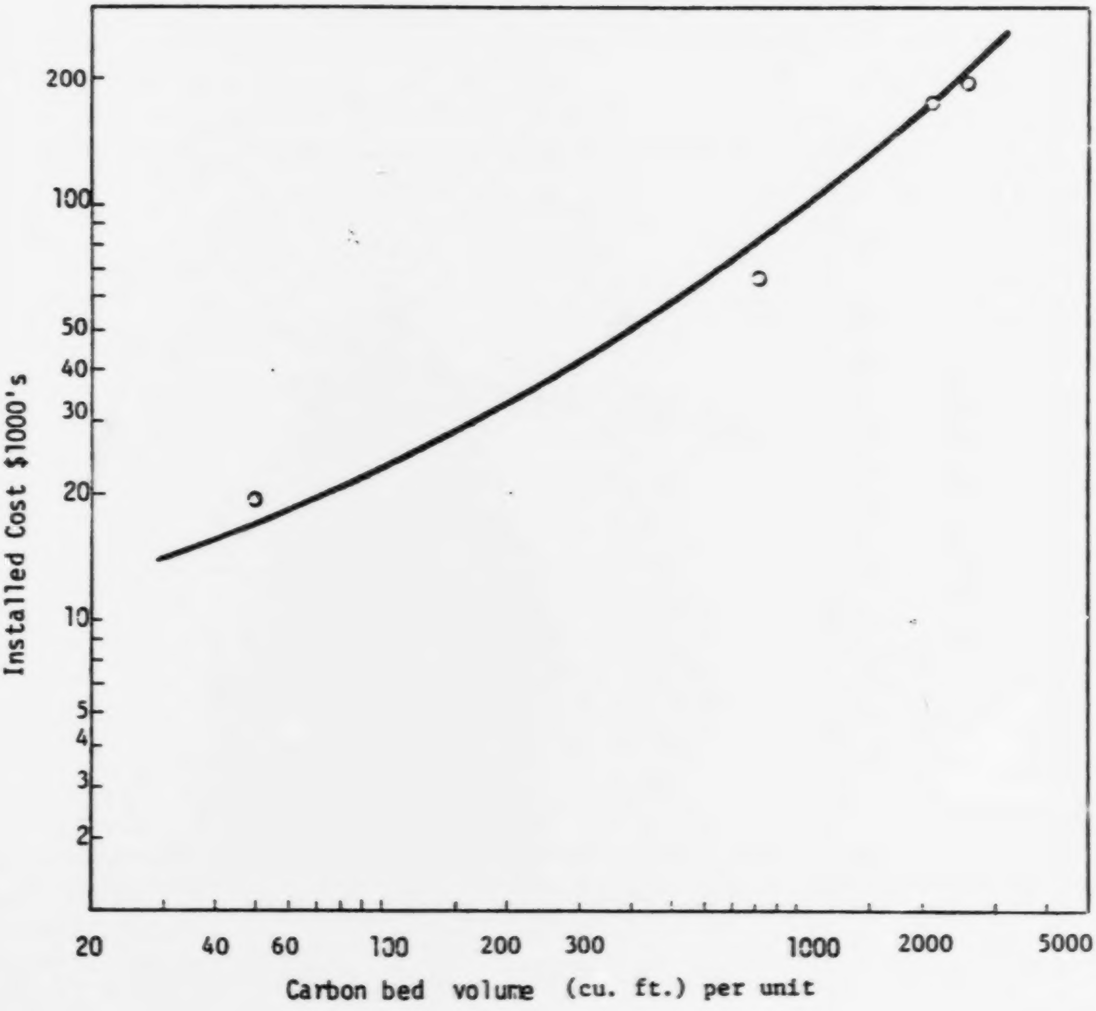
GRANULAR ACTIVATED CARBON ADSORPTION

MAJOR EQUIPMENT

INSTALLED COST

Costs include adsorbers, building foundation and feed pumps.

Costs do not include piping, electrical, mechanical, painting, contr. OH&P, Engineering, etc.



1. Carbon bed volume per unit ______ cu. ft. (From line 2, Fig. B-3)
2. Installed cost per unit $________.
3. Number of units _________. (From line 3, Fig. B-3)
4. Total installed cost $______ . (line 2 x line 3)

FIGURE C-4.1

OZONE

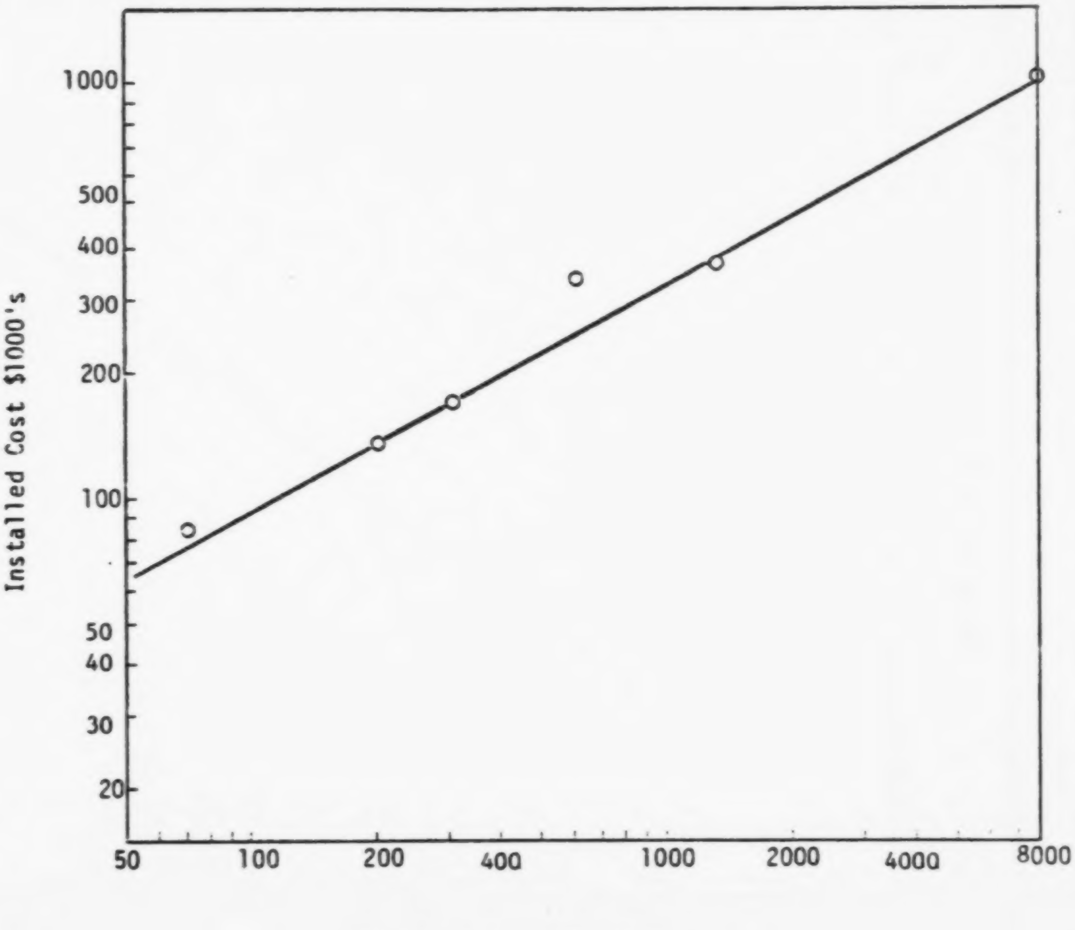
MAJOR EQUIPMENT (generation)

INSTALLED COST

(exclusive of contactor - see C-4.2)

Installed cost includes normal foundations, equipment, building with insulation windows and door.

Costs do not include piping, diffusers, electrical, contr. OH&P, engineering, instrumentation, controls, etc.



1. Required Ozone (lbs/day) _______. (From Table 1, page ii)
2. Installed cost $_________.

FIGURE C-4.2

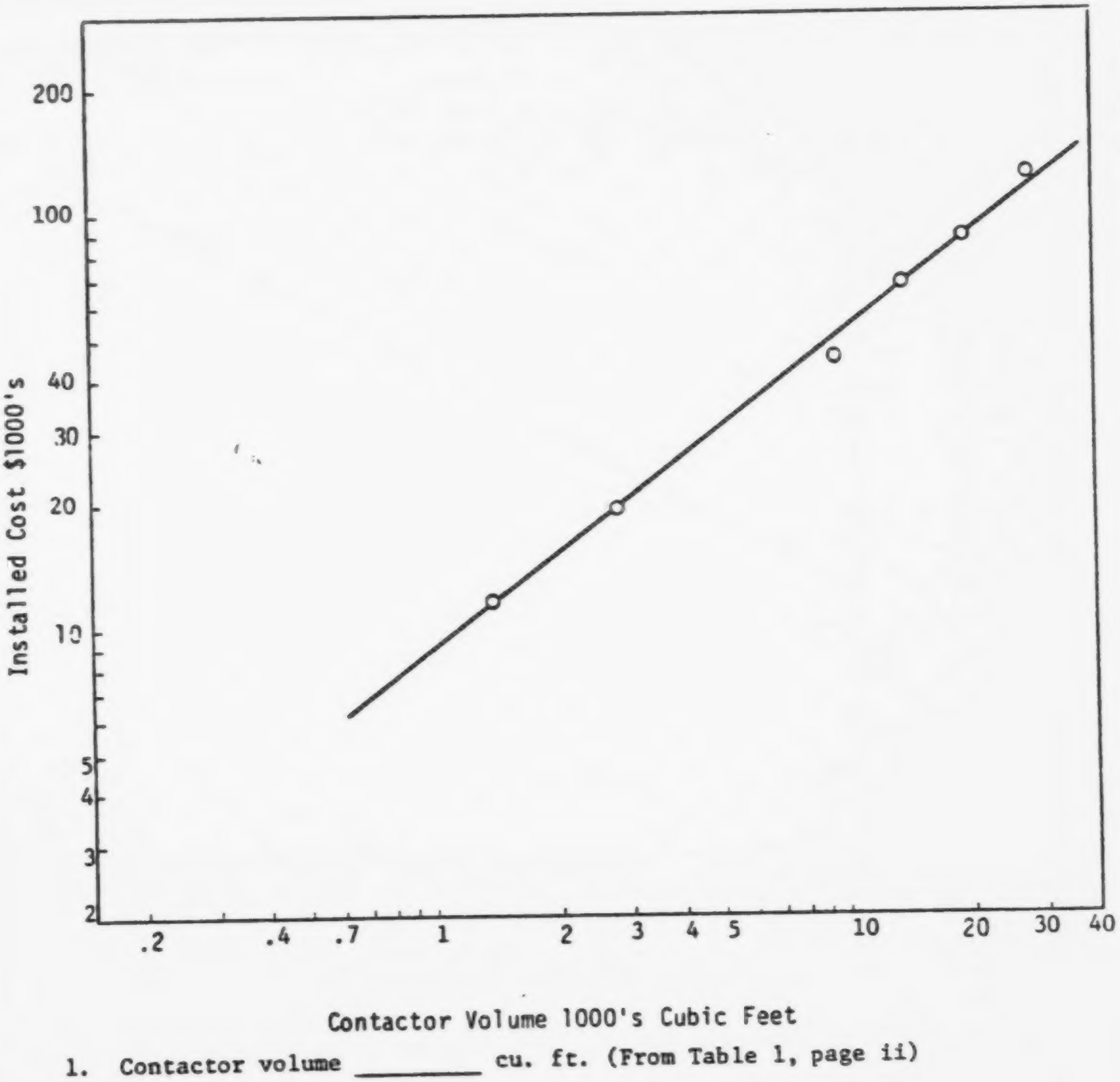
OZONE

MAJOR EQUIPMENT (CONTACTOR)

(exclusive of generation equipment - see C-4.1)

Installed cost includes tankage and normal foundation.

Cost does not include piping, diffusers, contr. OH&P, engineering, etc.



1. Contactor volume _________ cu. ft. (From Table 1, page ii)

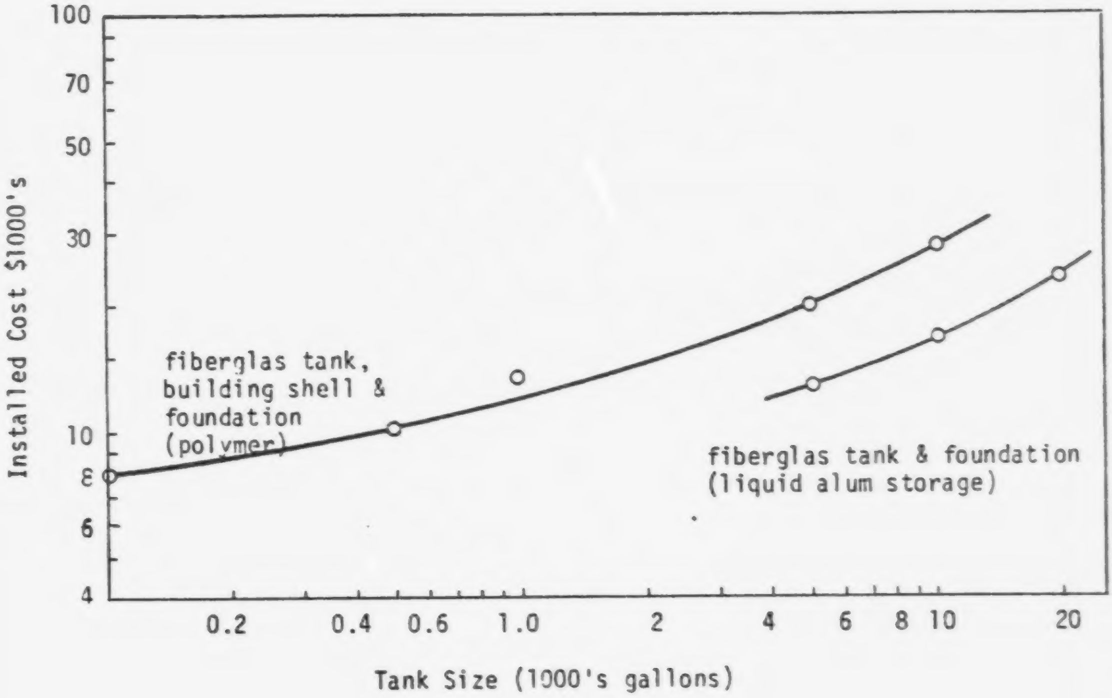
2. Installed cost $_______.

CHEMICAL STORAGE TANKS

Cost of polymer tank includes fiberglas tank - building - foundation and metering pumps.

Cost of alum tank includes fiberglas tank, foundation and feed pumps. Minimum tank size of 4000 gallons, is based on minimum size for truckload delivery of liquid alum.

Costs do not include controls, mixers or mix tanks, heaters, piping, electrical, contractor OH&P, engineering, etc.



1. Alum tank size __________ gallons (From line 2, Fig. B-5)
2. Installed Alum tank cost $ ____________.
3. Polymer tank size ____________ gallons (From line 4, Fig. B-5)
4. Installed polymer cost $ ________.

COST OF TREATING ADDITIONAL FLOW IN EXISTING BPT FACILITY

1. PRESENT WORTH CAPITAL COST OF YOUR EXISTING BPT FACILITY $_____________

2. BACKWASH FLOW (MGD) _________MGD

3. AVERAGE FLOW (MGD) __________MGD

4. PRO-RATED BPT COST = LINE 1 X $\frac{\text{LINE 2}}{\text{LINE 3}}$

5. PRO-RATED BPT COST = ($) $\frac{\rule{5em}{0.4pt}\ \text{MGD}}{\text{MGD}}$ = $__________*

* Enter this amount on Line 23, Figure C-0.0
Page II-8.

PART III

OPERATION & MAINTENANCE COSTS

PART III

OPERATION & MAINTENANCE COSTS

Each of the selected unit processes has associated annual operation and maintenance (O&M) costs which must be included in the fiscal analysis. These costs include labor costs for operation and maintenance, power costs, materials for operation and maintenance, and chemical costs for unit operations including carbon costs if required. The "D" series figures in this section were developed for identifying the various O&M cost factors for each unit process.

For purposes of instruction, the development of O&M costs for the multi-media filtration process will be explained. All costs are entered from the respective O&M cost curves onto Figure D-0.0, Annual Operation and Maintenance Estimating Form. Figure D-1.1.1 includes estimated annual man-hours required for O&M of the multi-media filtration process. The appropriate filter area on the x-axis is selected based upon sizing estimates developed in Part I of this estimating guide. Reading the intercept of this value with the curve shown on the graph, the annual man-hours from the y-axis can then be selected. This value is then entered in column X.X.1 on the line for multi-media filtration. This process is repeated using Figures D-1.1.2, D-1.1.3 and D-1.1.4, respectively for determining annual power, materials and chemical costs. The values are then entered in columns X.X.2, X.X.3 and X.X.4, respectively.

This process is repeated for each selected unit process included within your selected AWT system until all required values have been entered in Figure D-0.0. The columns are then totaled giving total annual O&M labor (man-hours) in column X.X.1 on line 6, total annual power (kw-hr) in column X.X.2 on line 7, total annual materials in $/yr in column X.X.3 on line 8 and total annual chemical cost in $/yr in column X.X.4 on line 9. The area specific labor cost ($/man-hour) applicable to the plant area is entered on line 10. The area specific power cost ($/kw-hr) is entered on line 11. All data for completing the annual O&M cost calculation as shown on line 12 of Figure D-0.0 are now available. The cost estimate for total annual O&M can be completed.

Figure D-0.0

ANNUAL OPERATING & MAINTENANCE ESTIMATING FORM

O&M COST ITEMS	OPERATING & MAINTENANCE M-hr/yr. X.X.1	POWER Kw-hr/yr. X.X.2	OPERATION & MAINTENANCE MATERIALS COST $/year X.X.3	CARBON OR CHEMICAL COST $/year X.X.4
1.1 MULTI-MEDIA FILTER				☒
2.1 REACTOR CLARIFIER				☒
2.2 GRAVITY SLUDGE THICKENER				☒
2.3 PRESSURE FILTRATION				
3.1 GRANULAR CARBON ABSORPTION				
4.1 OZONE				
5.1 ALUM				
5.2 POLYMER				
6. O&M LABOR M-hr/yr. total	☐	▨	▨	▨
7. POWER KW-hr/yr. total		☐	▨	▨
8. O&M MATERIALS COST $/yr. total			☐	▨
9. CHEMICAL COSTS $/yr. total				☐
10. LABOR COST $/M-hr		☐		
11. POWER COST $/Kw-hr		☐		
12. DAYS PER YEAR YOUR PLANT OPERATES		☐		
13. OPERATING ADJUSTMENT FACTOR = LINE 12÷365 =		☐		

14. ANNUAL SLUDGE DISPOSAL COST $/yr = _________ (From Figure D-2.3.4)

15. ADDITIONAL ANNUAL BPT O&M COST ________ (From Figure D-15)

16. ANNUAL O&M COST = $\{$(Line 6 x Line 10) + (Line 7 x Line 11) + Line 8 + Line 9 + Line 14$\}$ x Line 13 + Line 15 = $\{$(____ x ____) + (____ x ____) + _____ + _____ + _____$\}$ x _____ + _____ = ☐

NOTE: All Costs are Based on January 1979 dollars and do not include depreciation.

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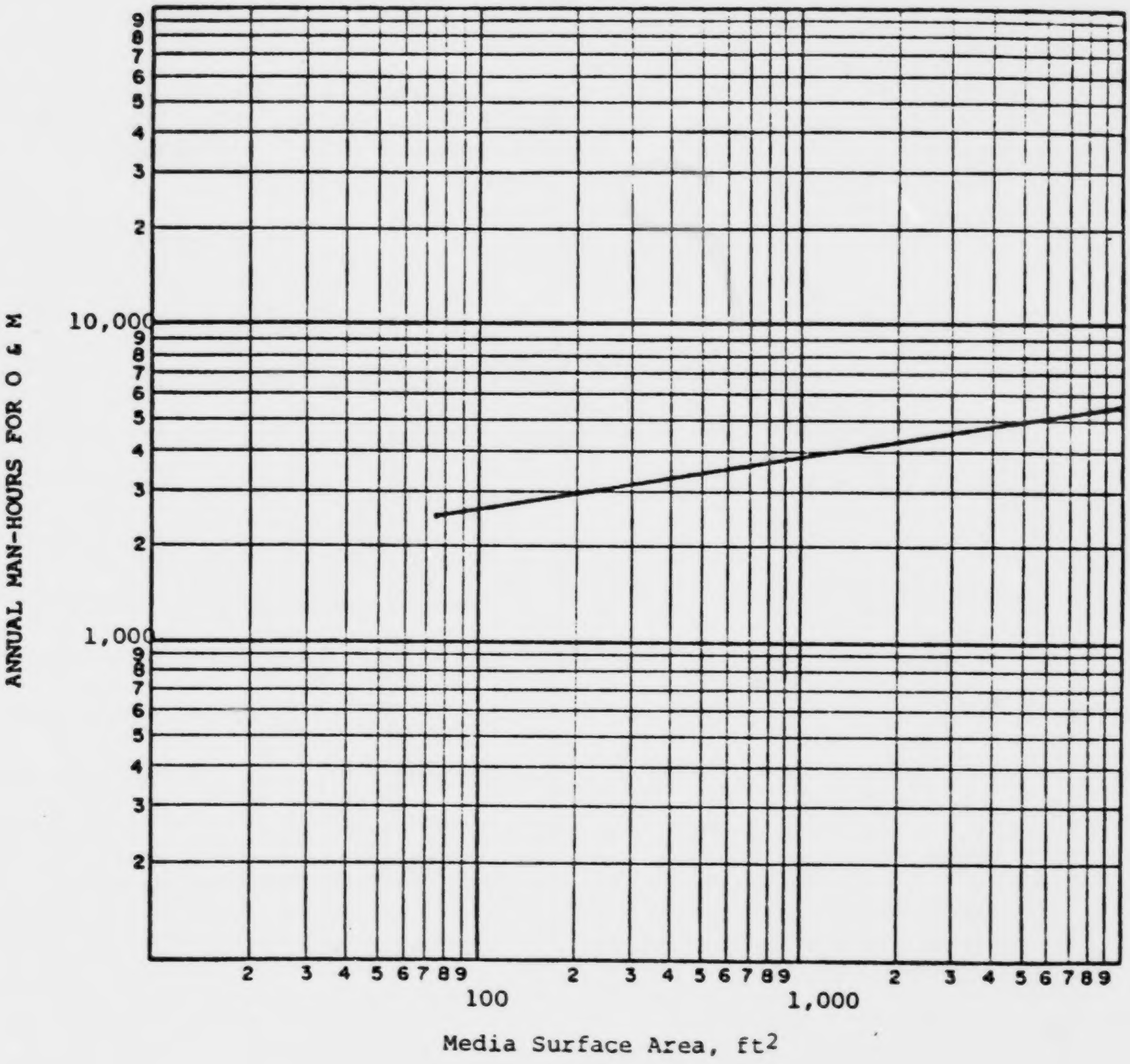


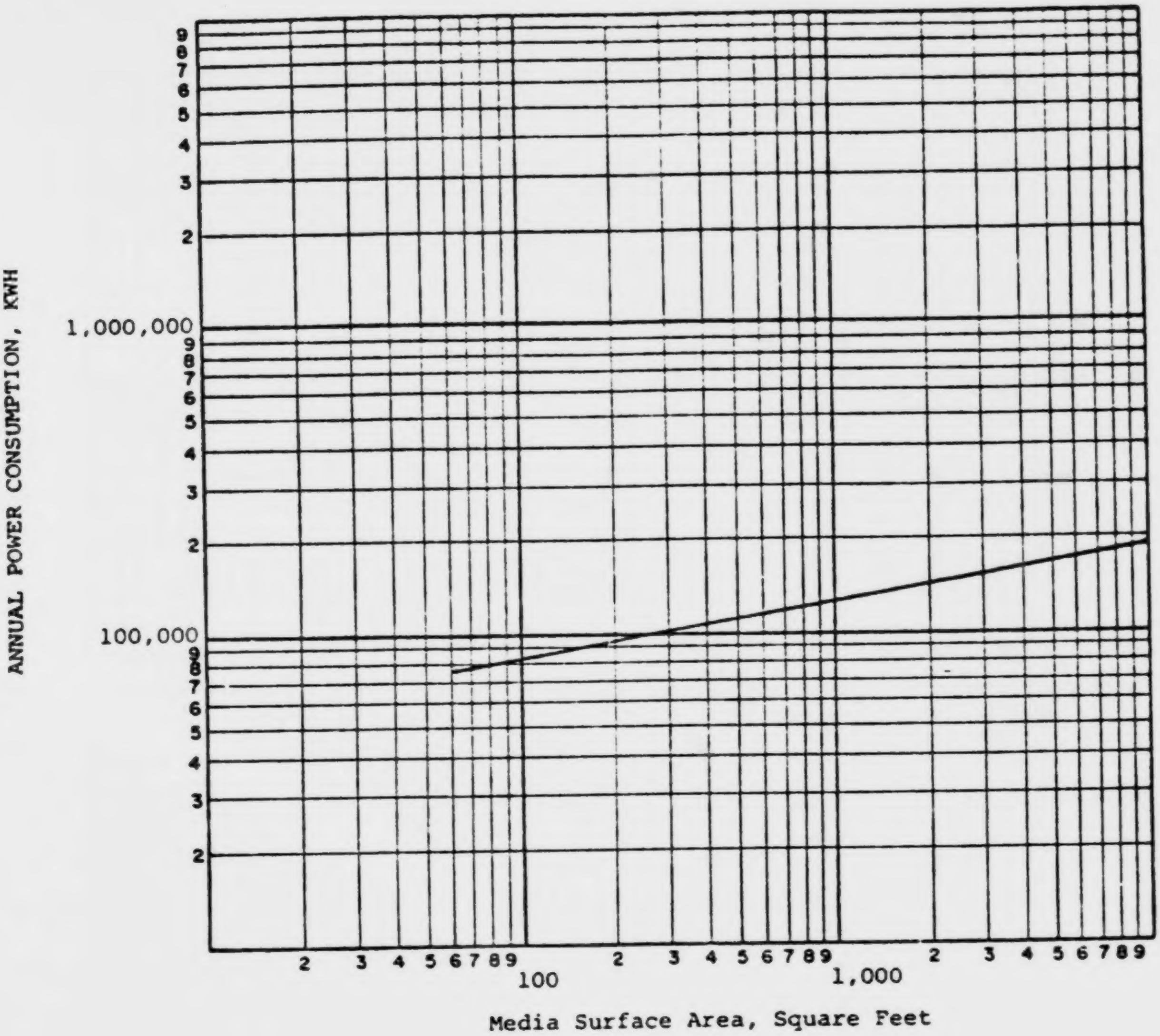
GRAVITY FILTRATION

(MULTI-MEDIA FILTRATION)

MAN-HOUR REQUIREMENTS

Reprinted from the Environmental Protection Technology Series "Appraisal of Powdered Activated Carbon Processes for Municipal Wastewater Treatment" EPA-600/2-77-156, Sept. 1977.

FIGURE D-1.1.2



GRAVITY FILTRATION

(MULTI-MEDIA FILTRATION)

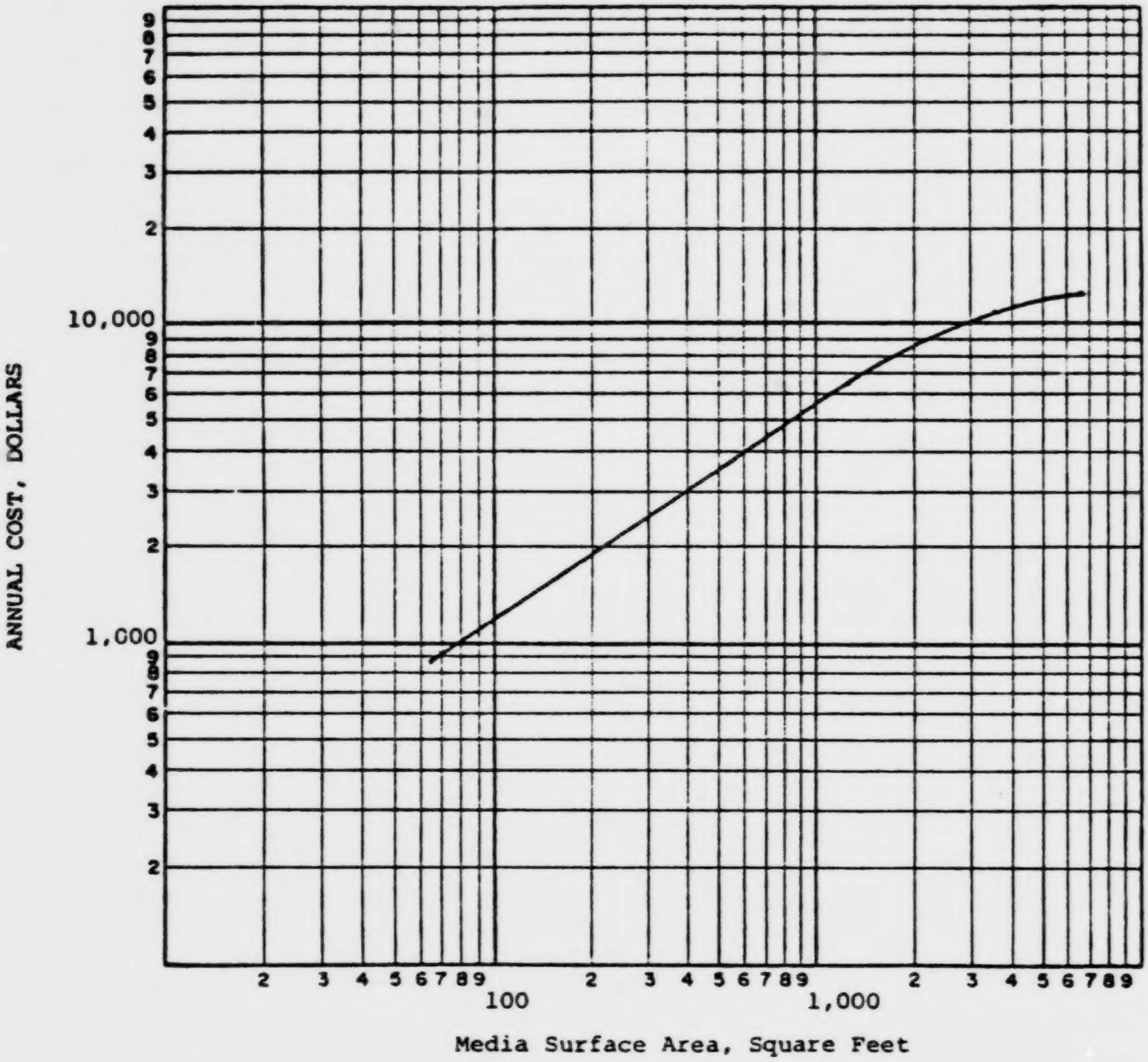
POWER REQUIREMENTS

(Backwash - 2/24 Hours)

Curve 53

See note on Figure D-1.1.1

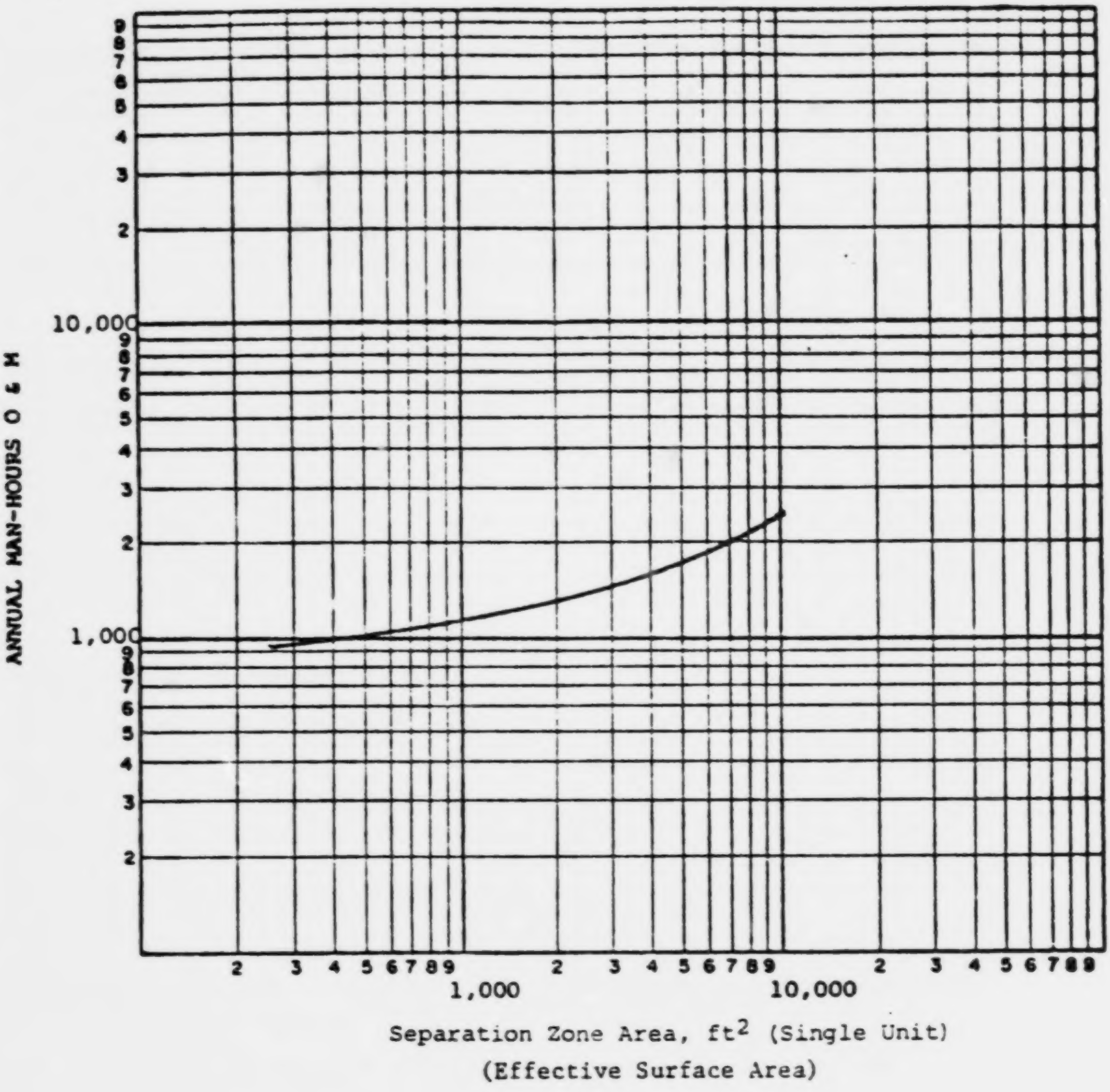
FIGURE D-1.1.3



GRAVITY FILTRATION
(MULTI-MEDIA FILTRATION)
MAINTENANCE MATERIAL COSTS

Curve 54

See note on Figure D-1.1.1



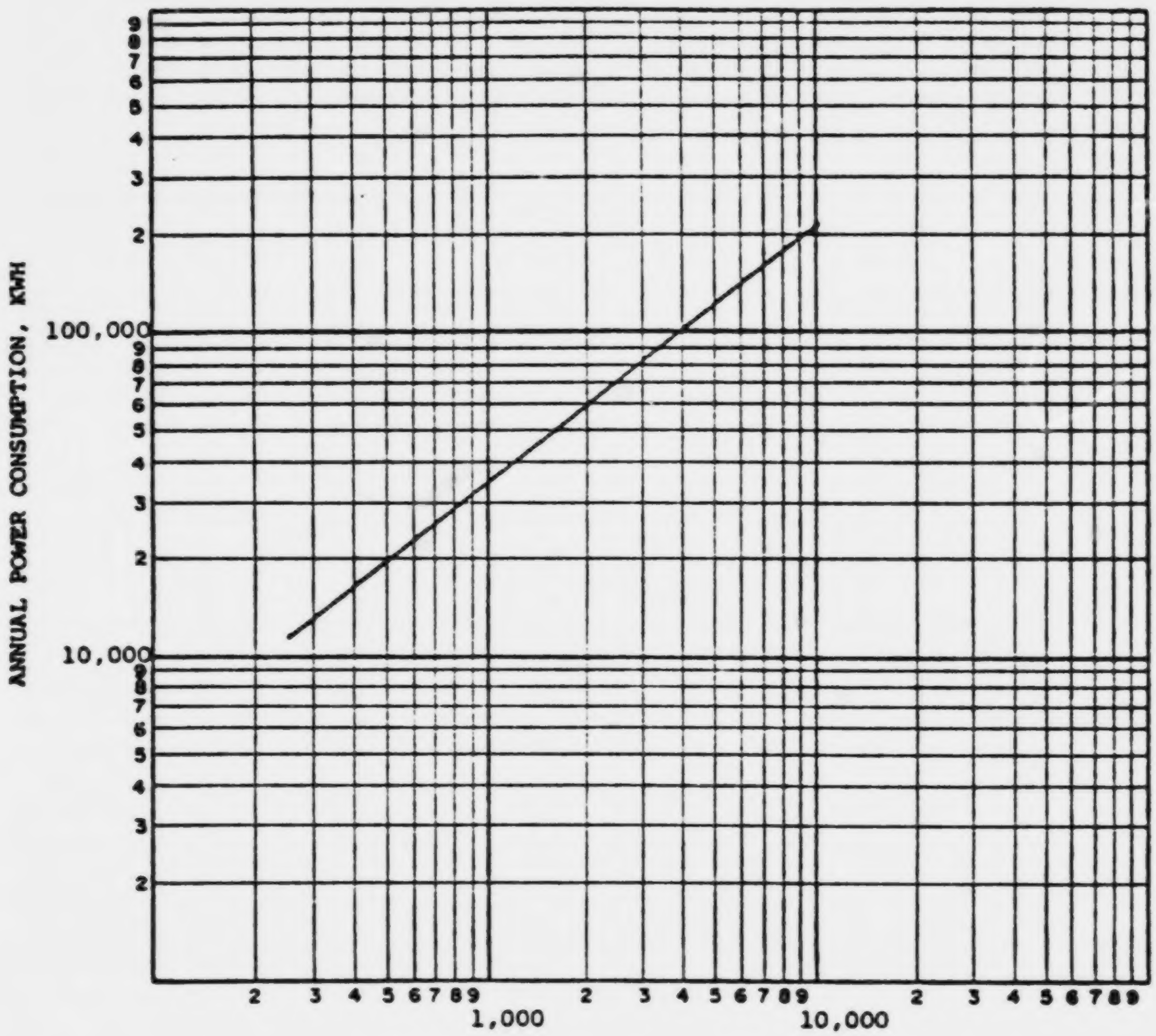
REACTOR CLARIFIER

MAN-HOUR REQUIREMENTS

NOTE: Multiply single unit requirement (from above curve) by the number of units to obtain total man-hour requirement.

Curve 49

See note on Figure D-1.1.1



Separation Zone Area, ft^2 (Single Unit)
(Effective Surface Area)

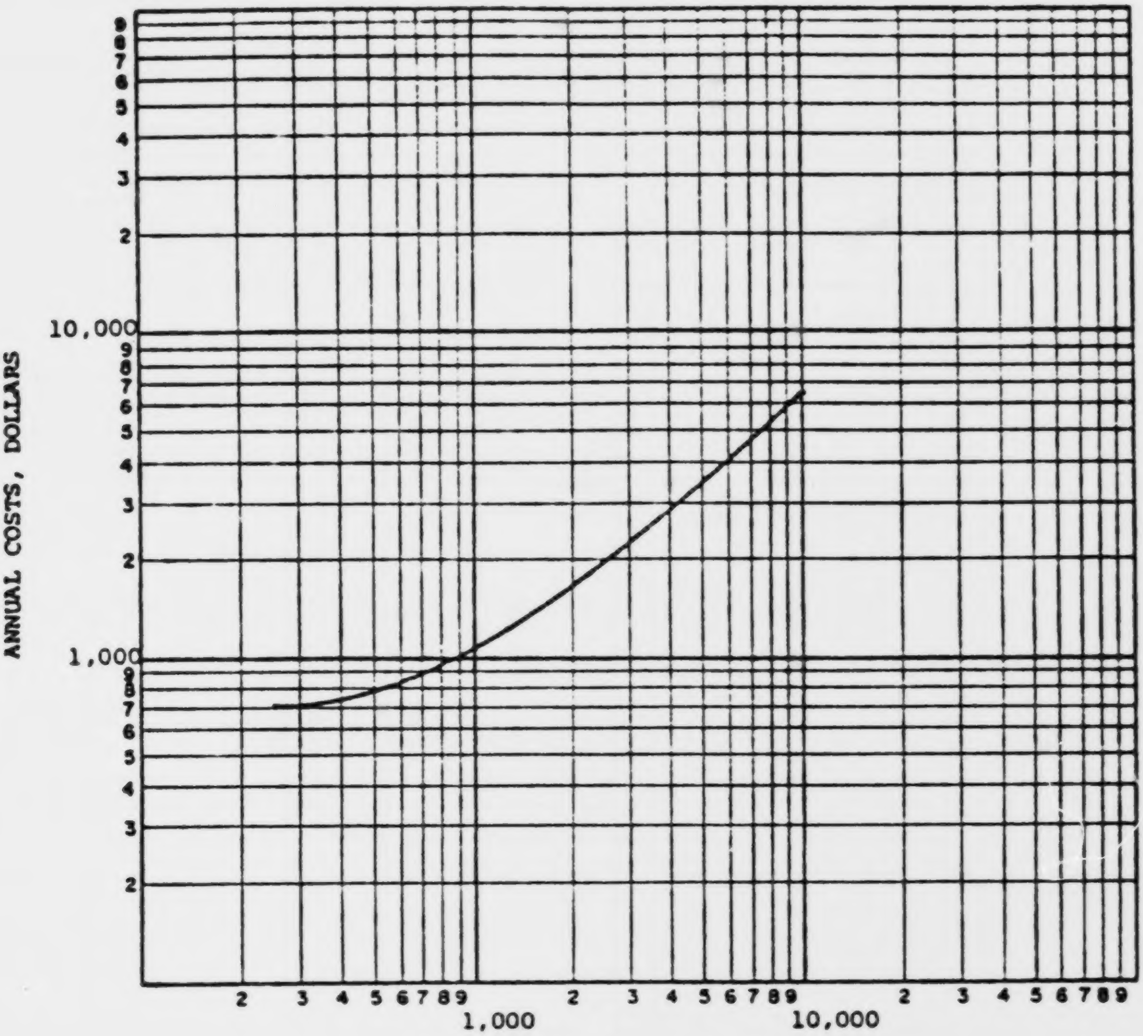
REACTOR CLARIFIER

POWER REQUIREMENTS

NOTE: Multiply single unit requirement (from above curve) by the number of units to obtain the total man-hour requirement.

Curve 50

See note on Figure D-1.1.1



Separation Zone, ft^2 (Single Unit)
(Effective Surface Area)

REACTOR CLARIFIER

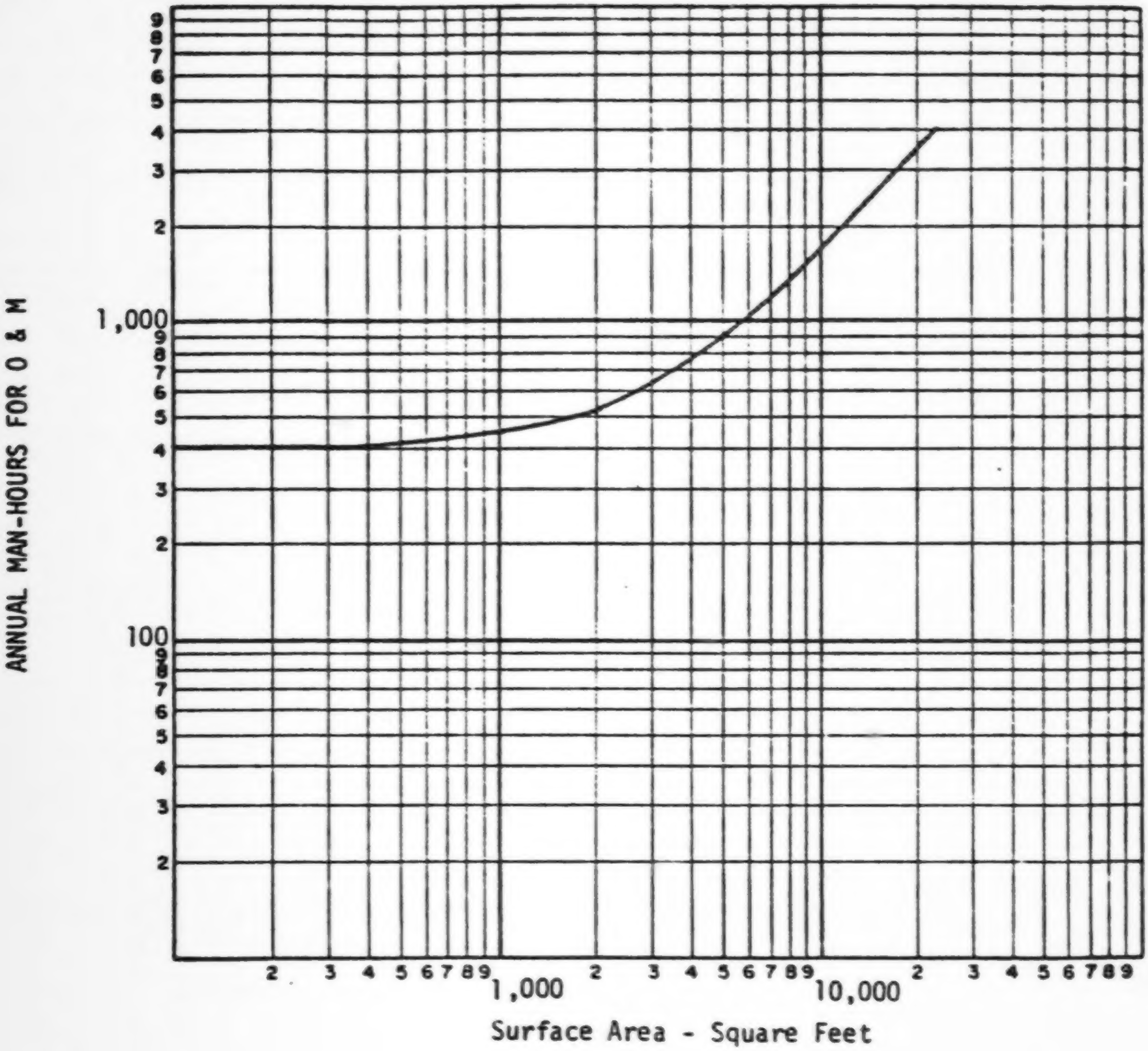
MAINTENANCE MATERIAL COSTS

NOTE: Multiply single unit requirement (from above curve by the number of units to obtain the total man-hour requirement.

Curve 51

See note on Figure D-1.1.1

FIGURE D-2.2.1

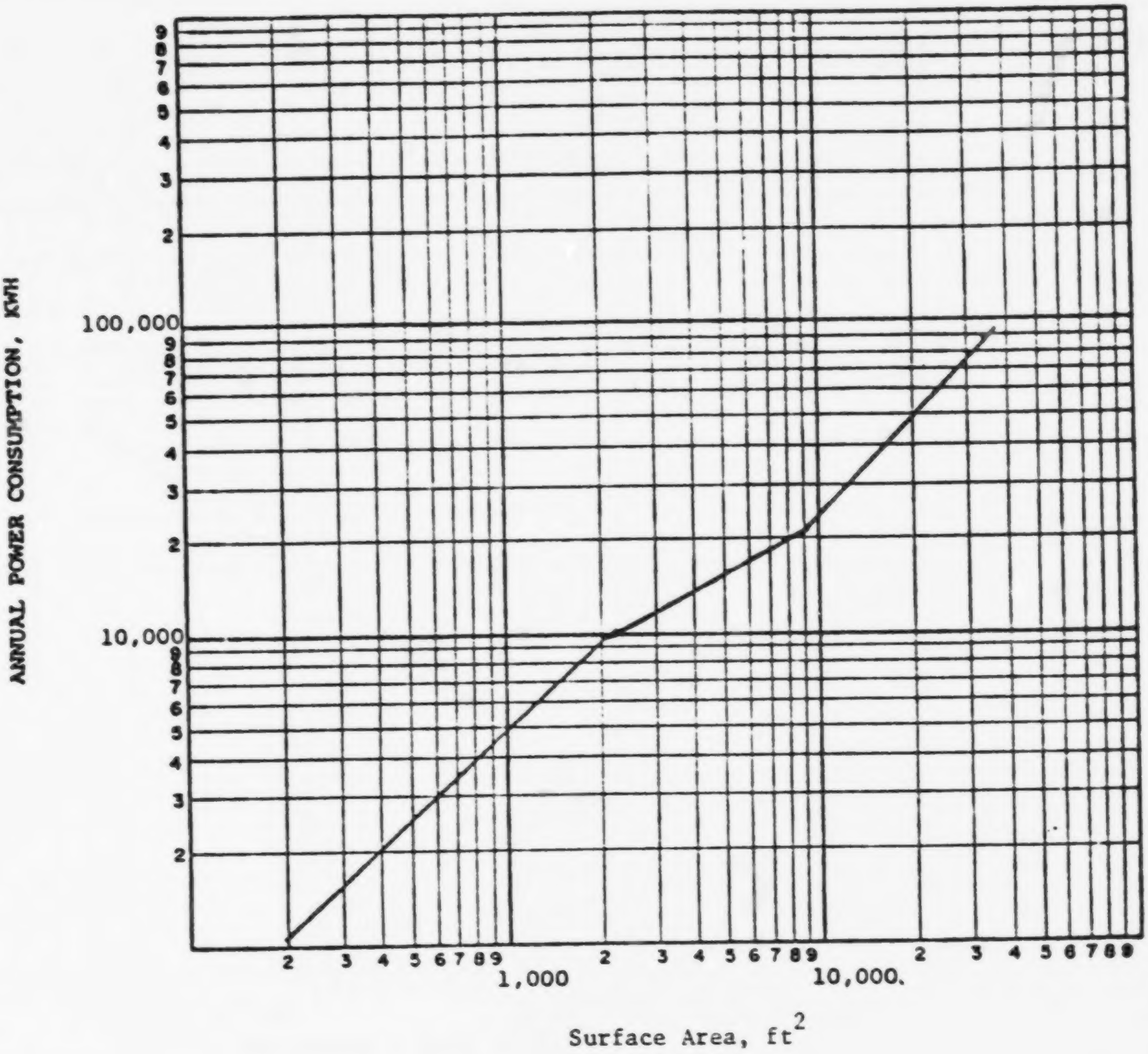


GRAVITY THICKENING

MAN-HOUR REQUIREMENTS

Curve 66

See note on Figure D-1.1.1

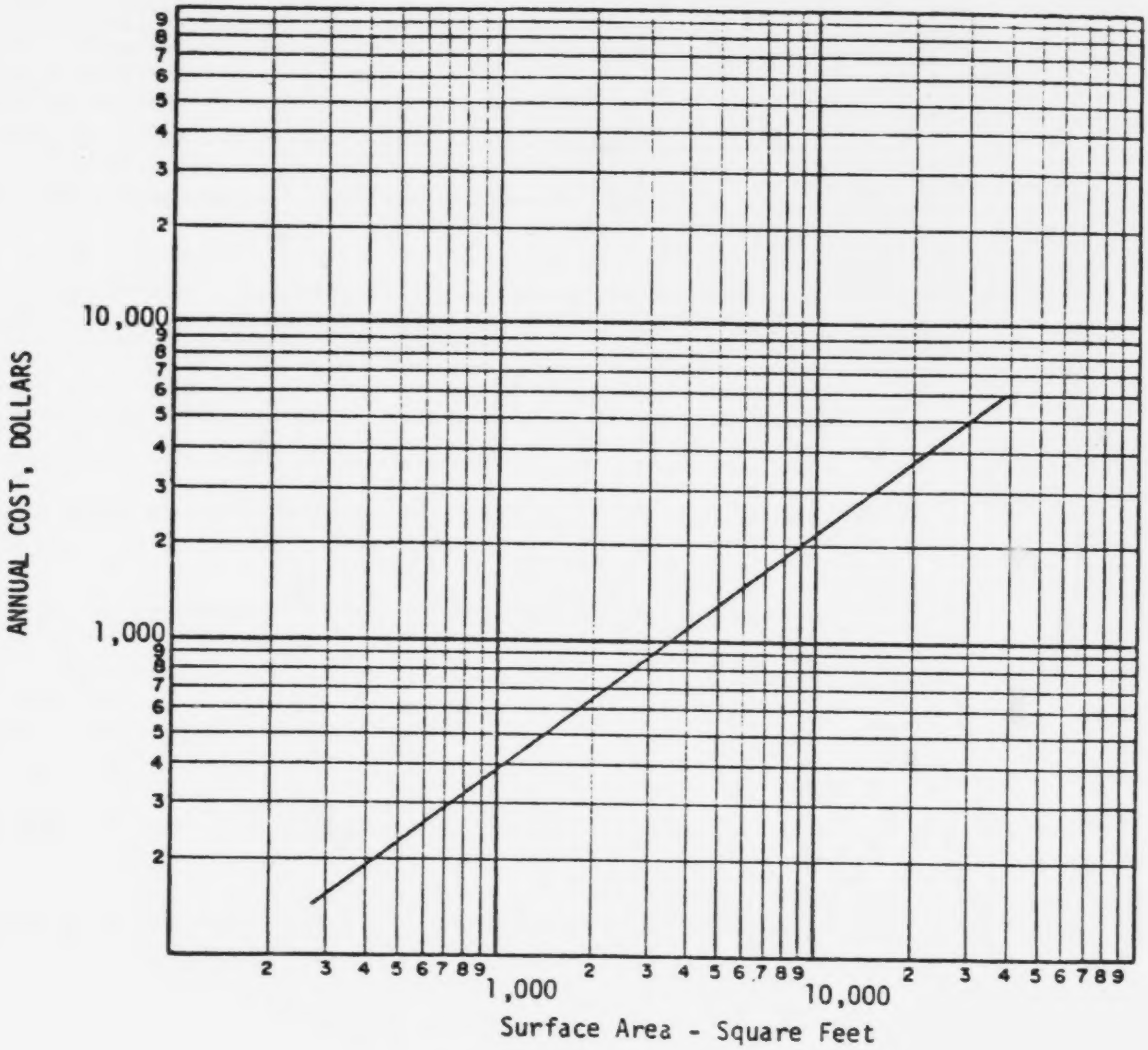


GRAVITY THICKENING

POWER REQUIREMENTS

Curve 67

See note on Figure D-1.1.1

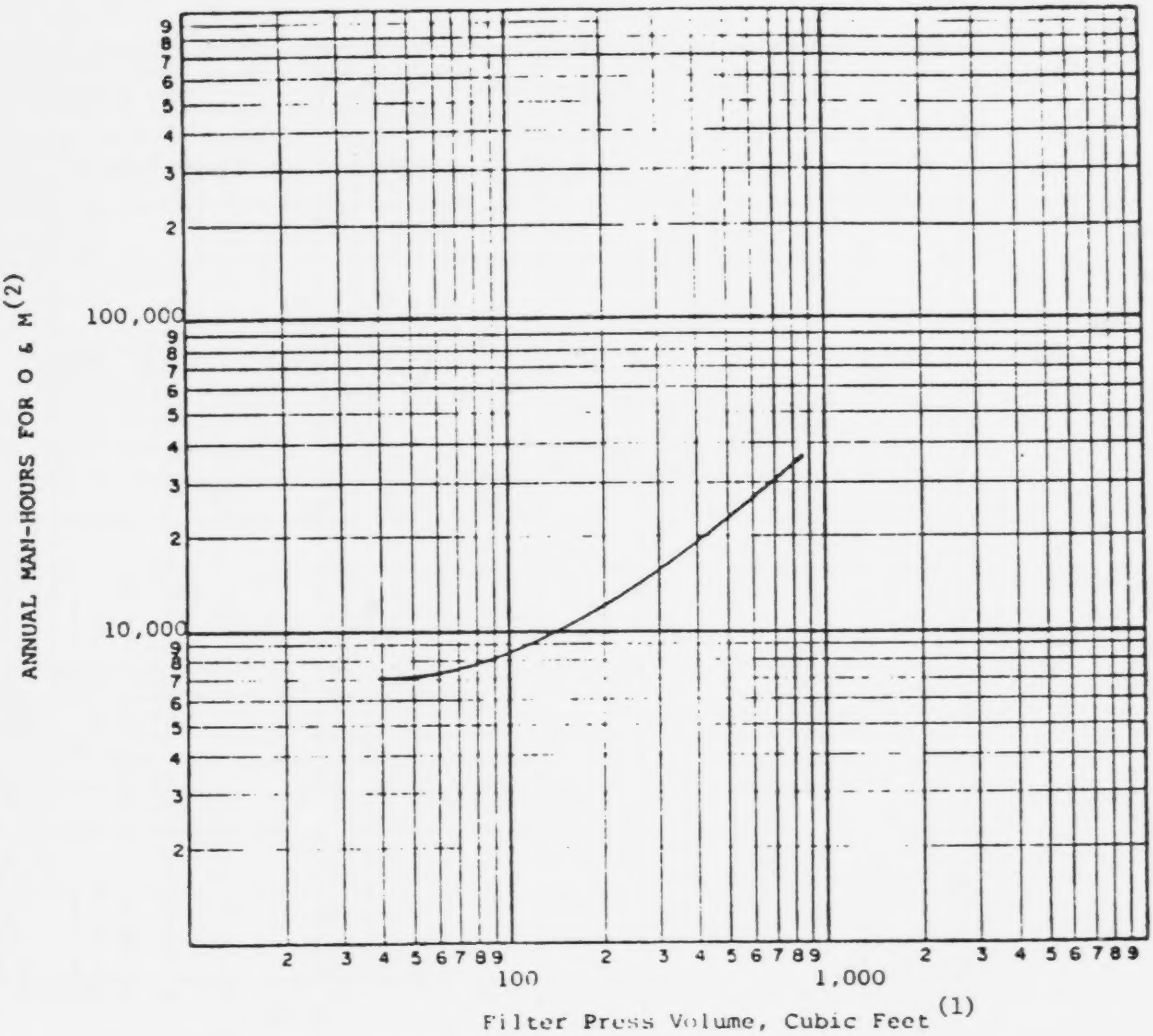


GRAVITY THICKENING

MAINTENANCE MATERIAL COSTS

Curve 68

See note on Figure D-1.1.1



PRESSURE FILTRATION, LABOR
(BASED ON CONTINUOUS, 7 DAY/WEEK OPERATION, 2 HR CYCLE)

MAN-HOUR REQUIREMENTS

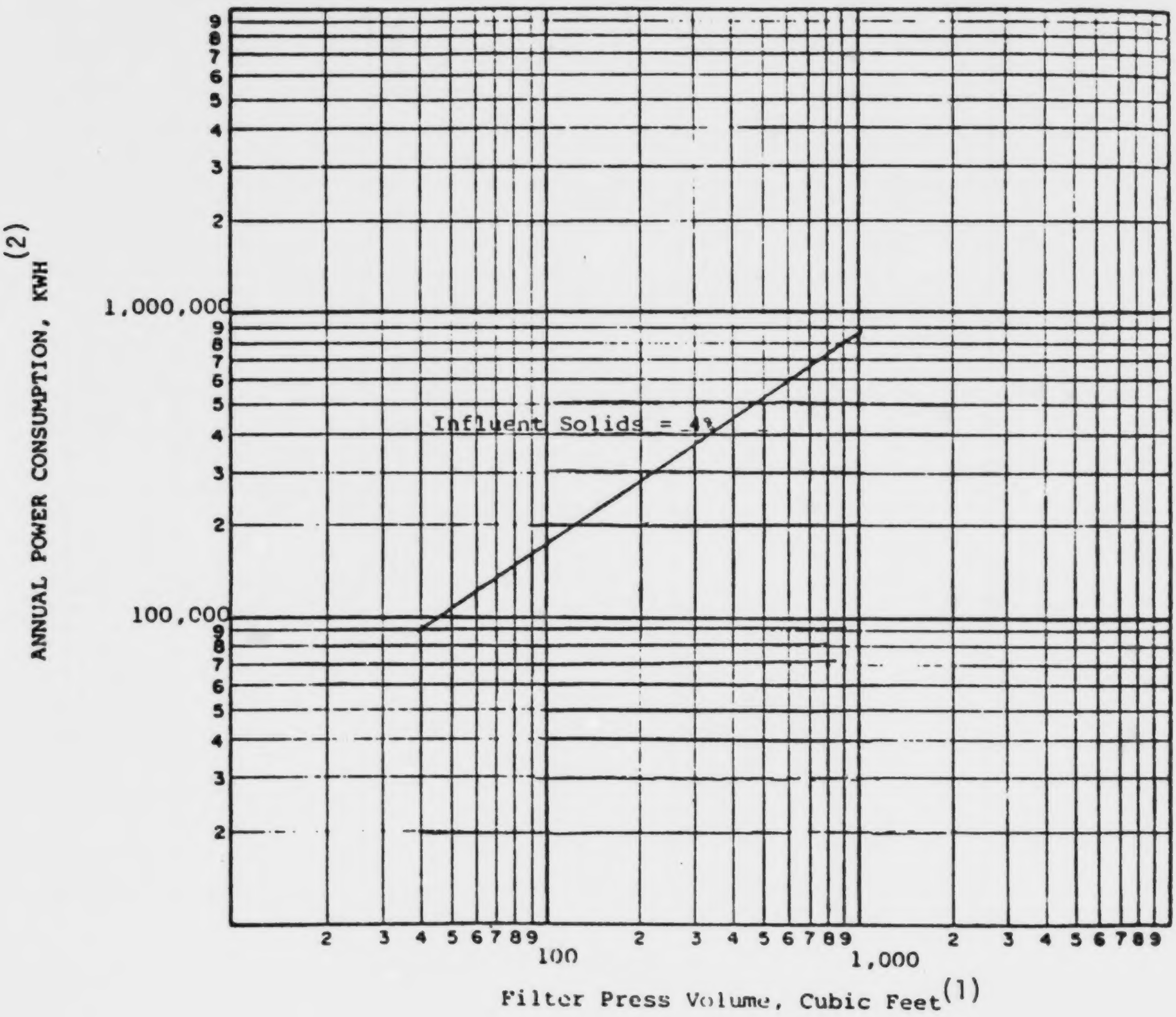
(1) Convert from lbs/day of solids to Filter Press Volume for use of this curve.

$$\text{Press Volume (cubic feet)} = \frac{\text{lbs/day of solids}}{\frac{\text{8 hr day}}{\text{2 hr cycles}} \times \left(\frac{\text{35\% solids conc}}{\text{100\%}}\right) \times 75 \ \frac{\text{lbs}}{\text{cu.ft.}} \ \text{cake density}}$$

(2) Reduce annual man-hour requirements by 16 hrs/day x 365 days/year = 5840

Curve 107

FIGURE D-2.3.2



PRESSURE FILTRATION, POWER

(BASED ON CONTINUOUS, 7 DAY/WEEK OPERATION, 2 HR CYCLE)

POWER REQUIREMENTS

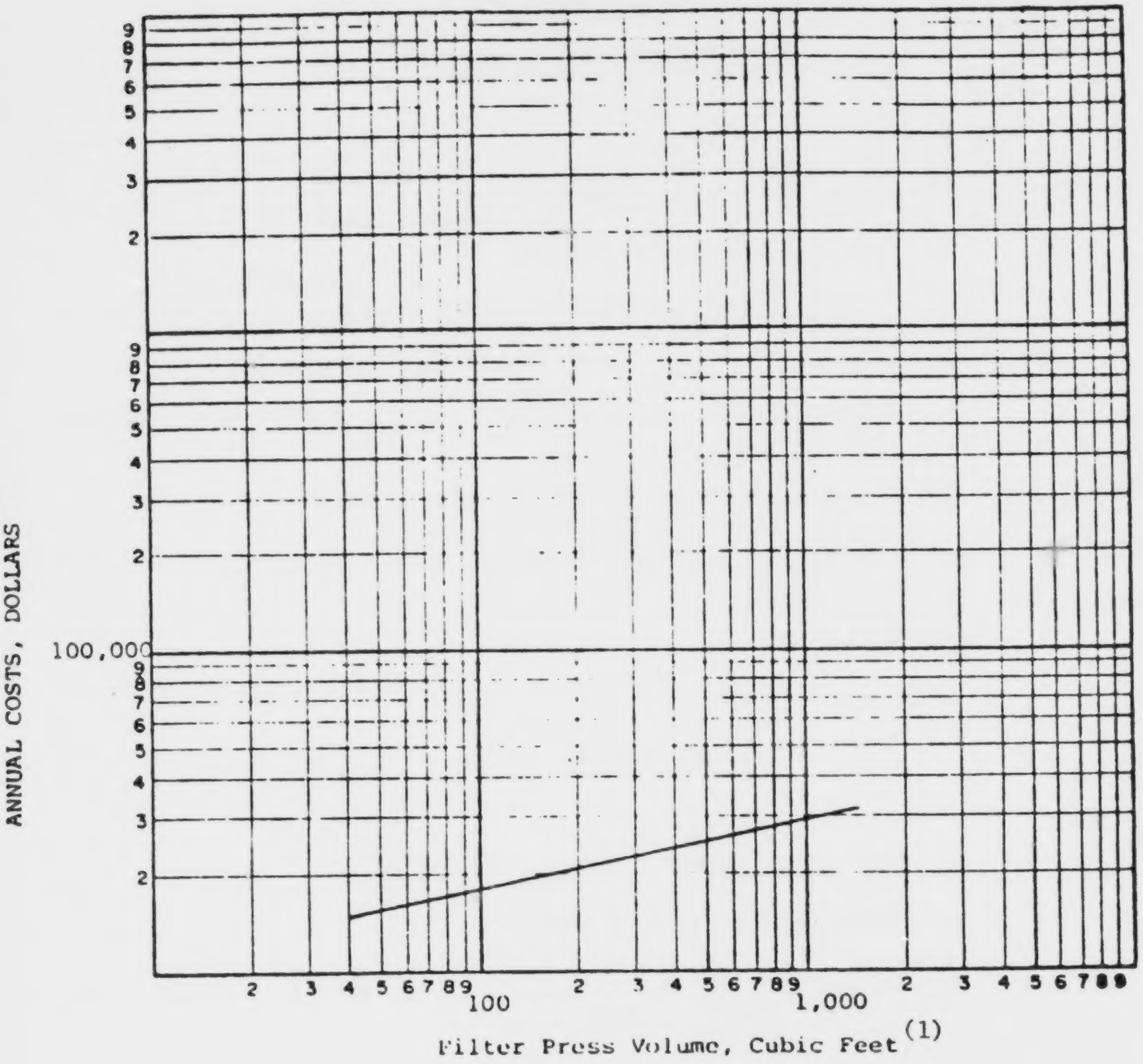
(1) Note convert from lbs/day of solids to Filter Press volume for use of this curve.

$$\text{Press Volume (cu.ft.)} = \frac{\text{lbs/day of solids}}{\left(75\ \frac{\text{lbs}}{\text{cu.ft.}}\ \text{cake density}\right) \times \left(\frac{\text{35\% solids conc. cake}}{100\%}\right) \times \frac{\text{8 hr day}}{\text{2 hr cycles}}}$$

(2) Divide Power consumption by $\frac{24\text{ hr}}{8\text{ hr}}$ = (3) for 8 hr per day operation.

Curve 108

FIGURE D-2.3.3



PRESSURE FILTRATION
(BASED ON CONTINUOUS, 7 DAY/WEEK OPERATION, 2 HR CYCLE)
MAINTENANCE MATERIAL COSTS

(1) Convert from lbs/day of solids to Filter Press Volume for use of this curve.

$$\text{Press Volume (cu. ft.)} = \frac{\text{lbs/day of solids}}{\frac{\text{8 hr day}}{\text{2 hr cycles}} \times \left(\frac{\text{35\% solids conc.}}{100\%}\right) \times 75\ \frac{\text{lbs}}{\text{cu.ft.}}\ \text{cake density}}$$

(2) Divide annual maintenance material costs by $\frac{24\text{ hr}}{8\text{ hr}}$ = (3) for 8 hr/day operation

Curve 109

PRESSURE FILTRATION

CHEMICAL & CONDITIONER COSTS

1. LOCAL COST OF BULK LIME $/lb ☐
2. LOCAL COST OF FILTER PRECOAT
   (FLY ASH OR DIATOMACEOUS EARTH) $/lb ☐
3. SLUDGE ________ lb/day (From Table 1, page ii)
4. ANNUAL CHEMICAL AND CONDITIONER COSTS FOR PRESSURE FILTRATION

ANNUAL COST = 365 days/yr x (LINE 3) x (LINE 1 x 0.2 + LINE 2 x 0.018)

ANNUAL COST = 365 days/yr x _____ lbs/day (_____ $/lb x 0.2+_____ $/lb x 0.018)

ANNUAL COST = $_______ per year

SLUDGE DISPOSAL COSTS

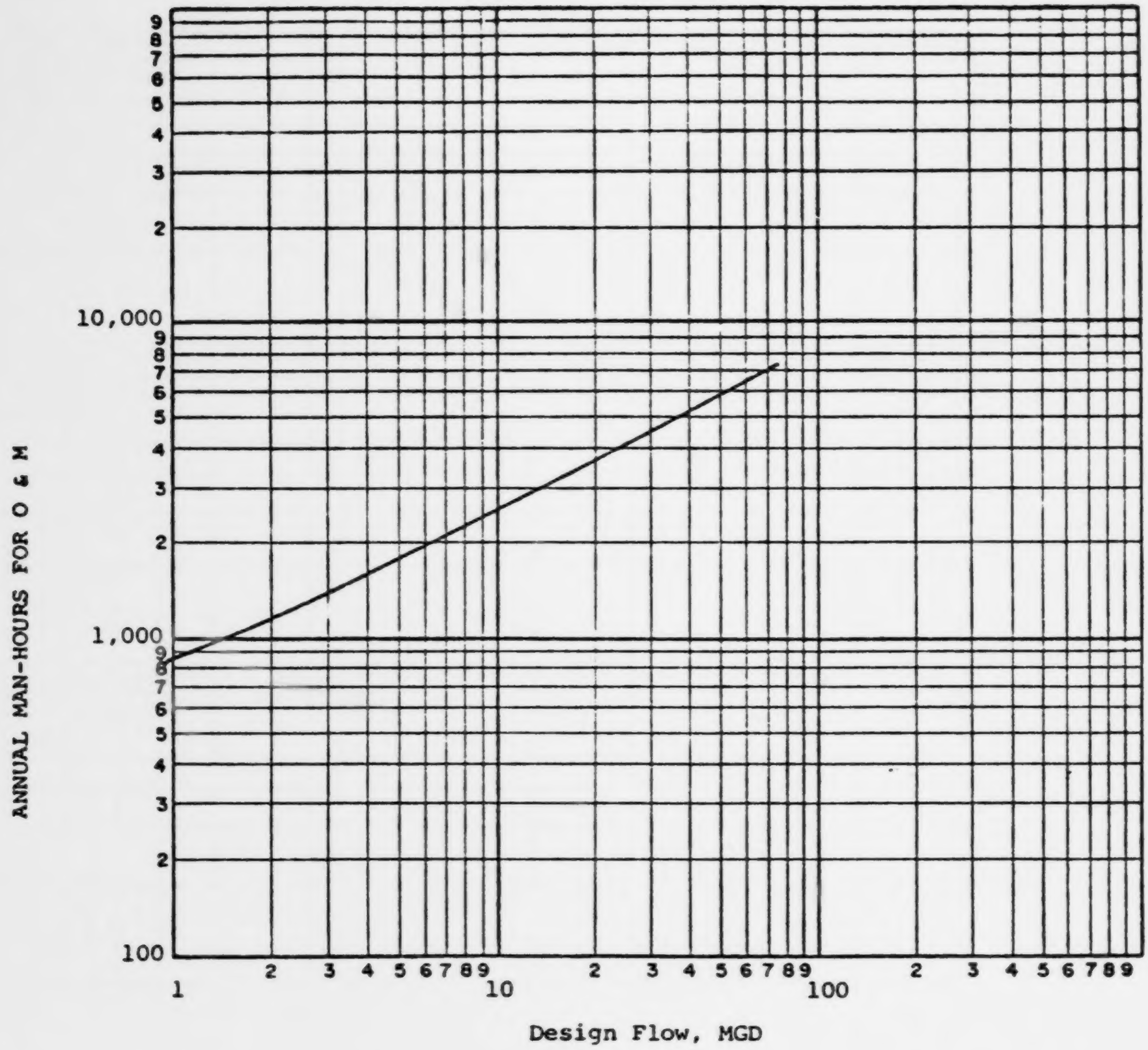
5. DISTANCE TO SLUDGE DISPOSAL SITE (MILES) _______ mi.
6. ANNUAL SLUDGE DISPOSAL COST

$$= \left\{ \frac{\text{sludge lb/day}}{.35\ \frac{\text{lb/dry}}{\text{lb/wet}} \times 2000\ \text{lb/ton}} \times (\$4/\text{ton} + \$0.2/\text{ton/mi} \times \text{Line 5} \right\}$$

x 365 days/yr

$$= \left\{ \frac{\_\_\_\_\_\_\ \text{lb dav}}{.35 \times 2000} \times (4 + .2 \times \_\_\_\_\_\ \text{mi}) \right\} \times 365$$

= $_____ per year (enter this value on line 14 of Fig. D-0.0)



GRANULAR CARBON ADSORPTION AND PUMPING

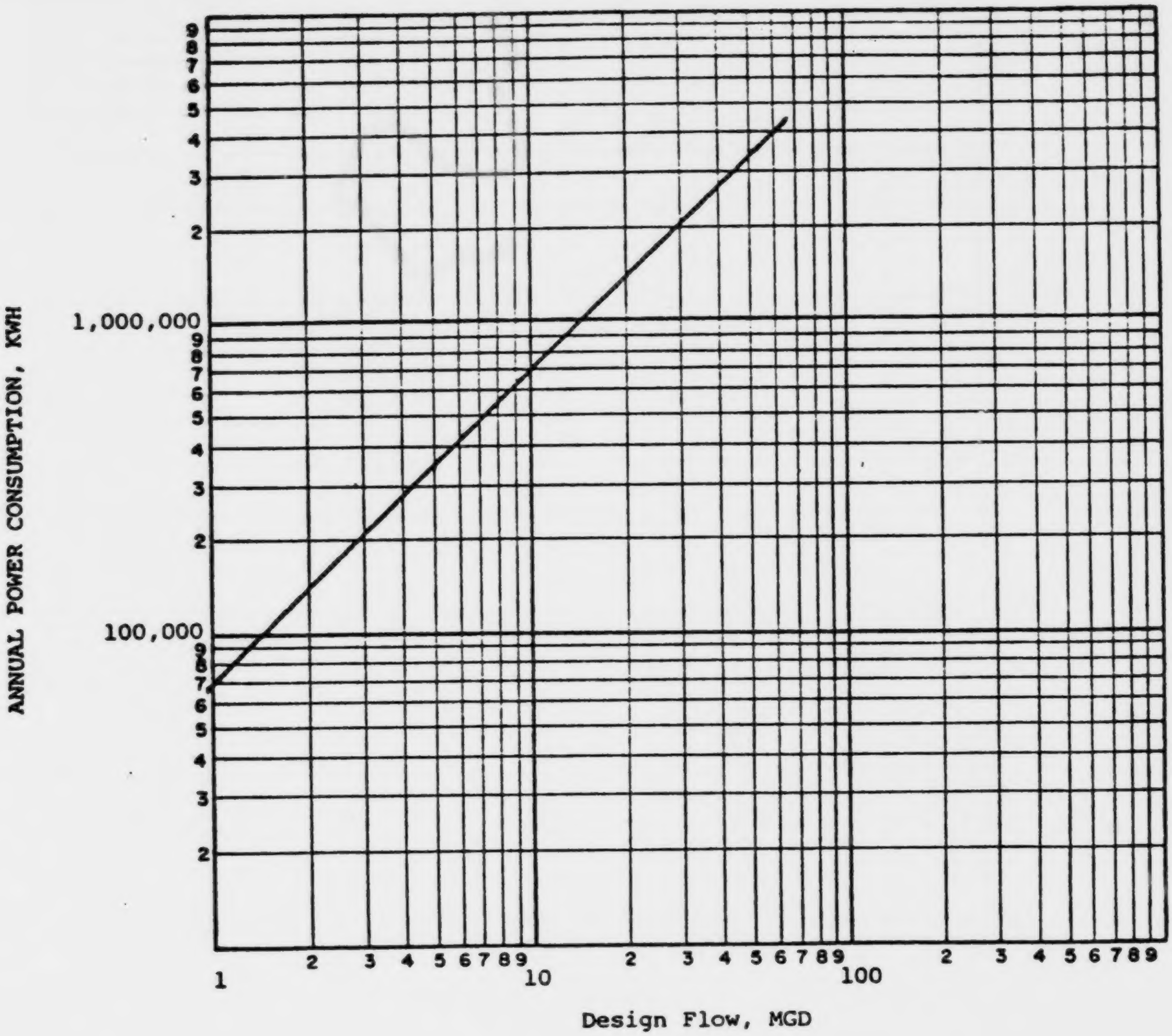
(30 minutes contact)

MAN-HOUR REQUIREMENTS

Curve 55

See Figure D-1.1.1

FIGURE D-3.1.2



GRANULAR CARBON ADSORPTION AND PUMPING

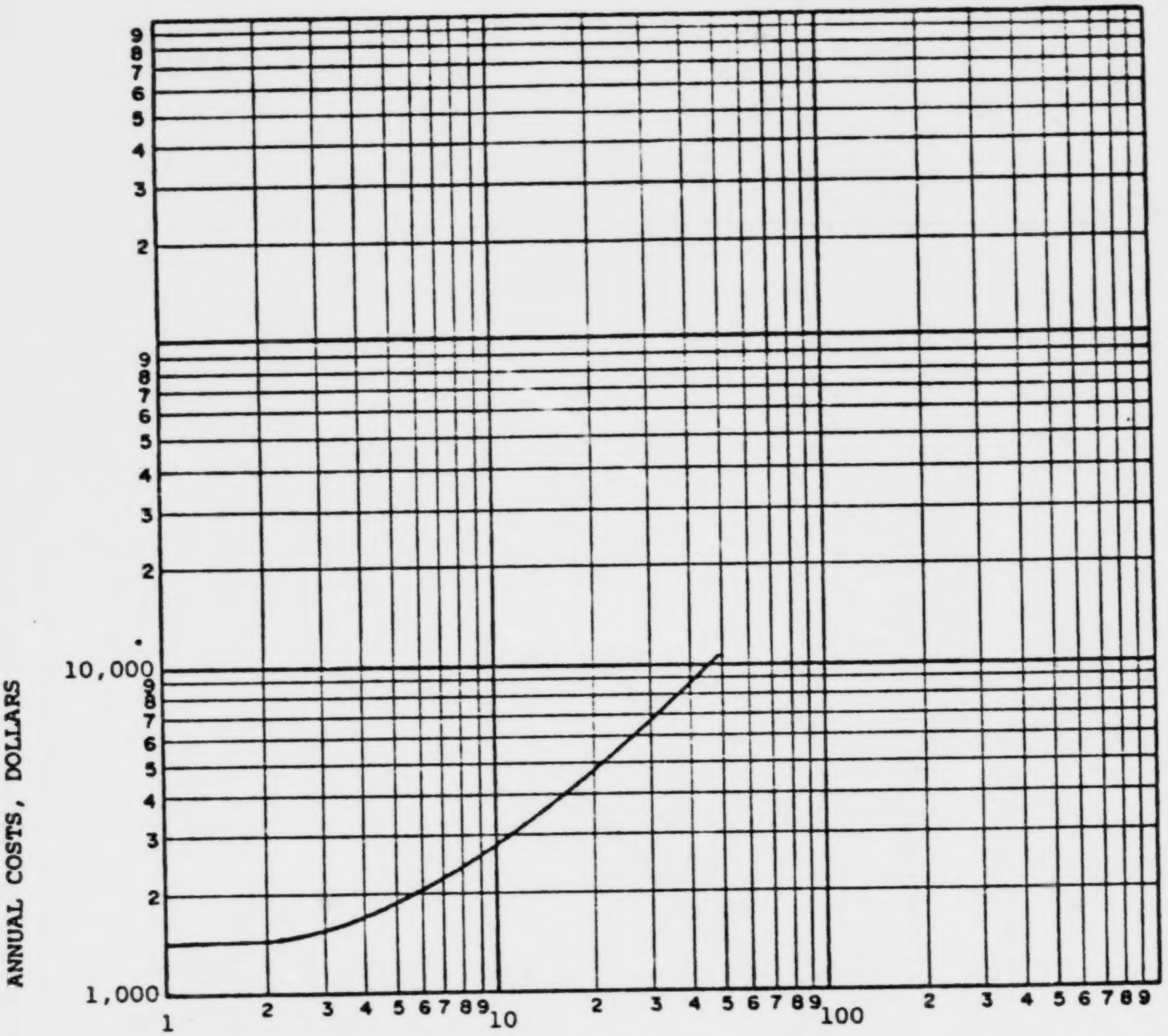
(30 minutes contact)

POWER REQUIREMENTS

Curve 56

See Figure D-1.1.1

FIGURE D-3.1.3



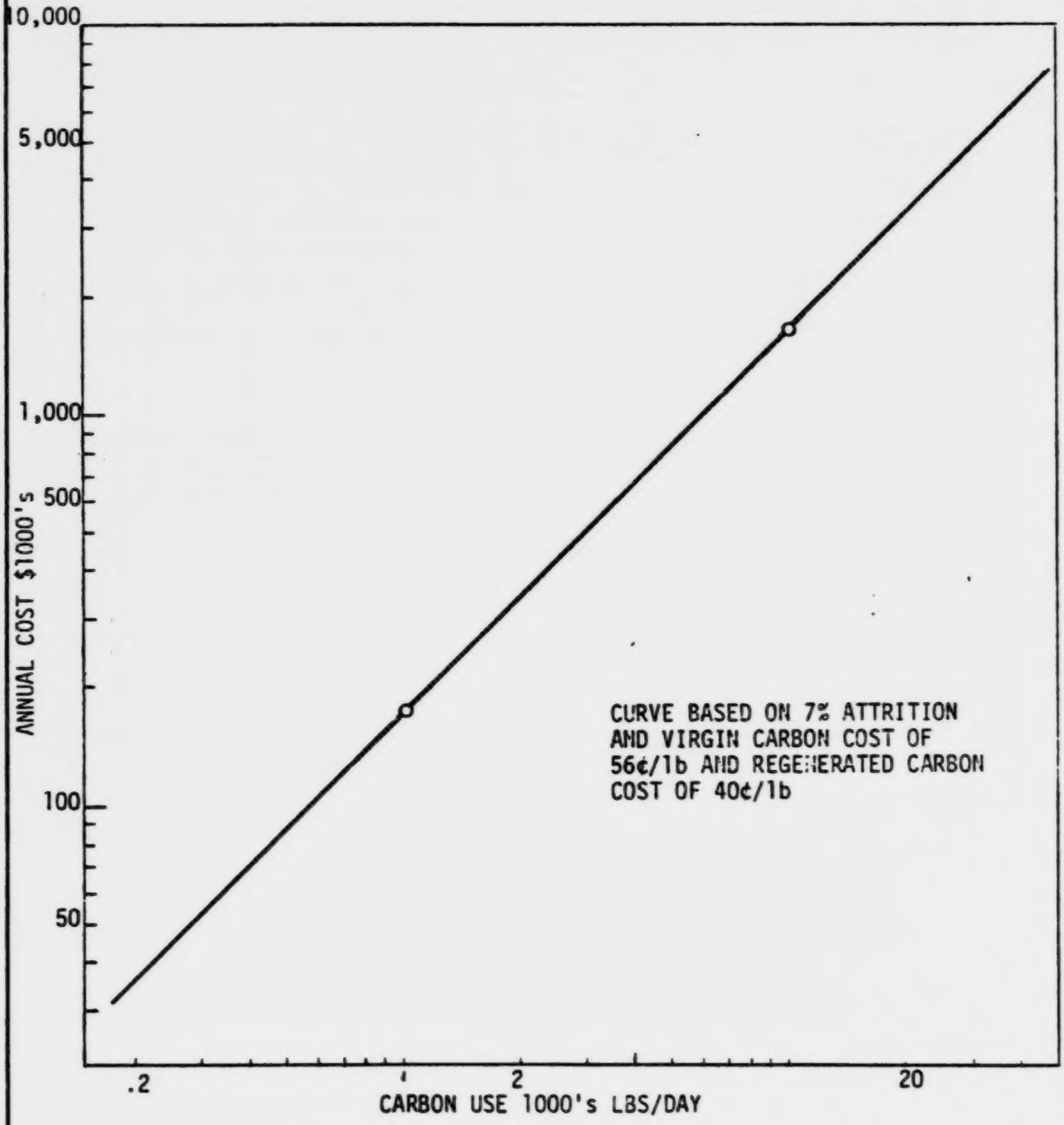
GRANULAR CARBON ADSORPTION AND PUMPING
(30 minutes contact)

MAINTENANCE MATERIALS

Curve 57

See Figure D-1.1.1

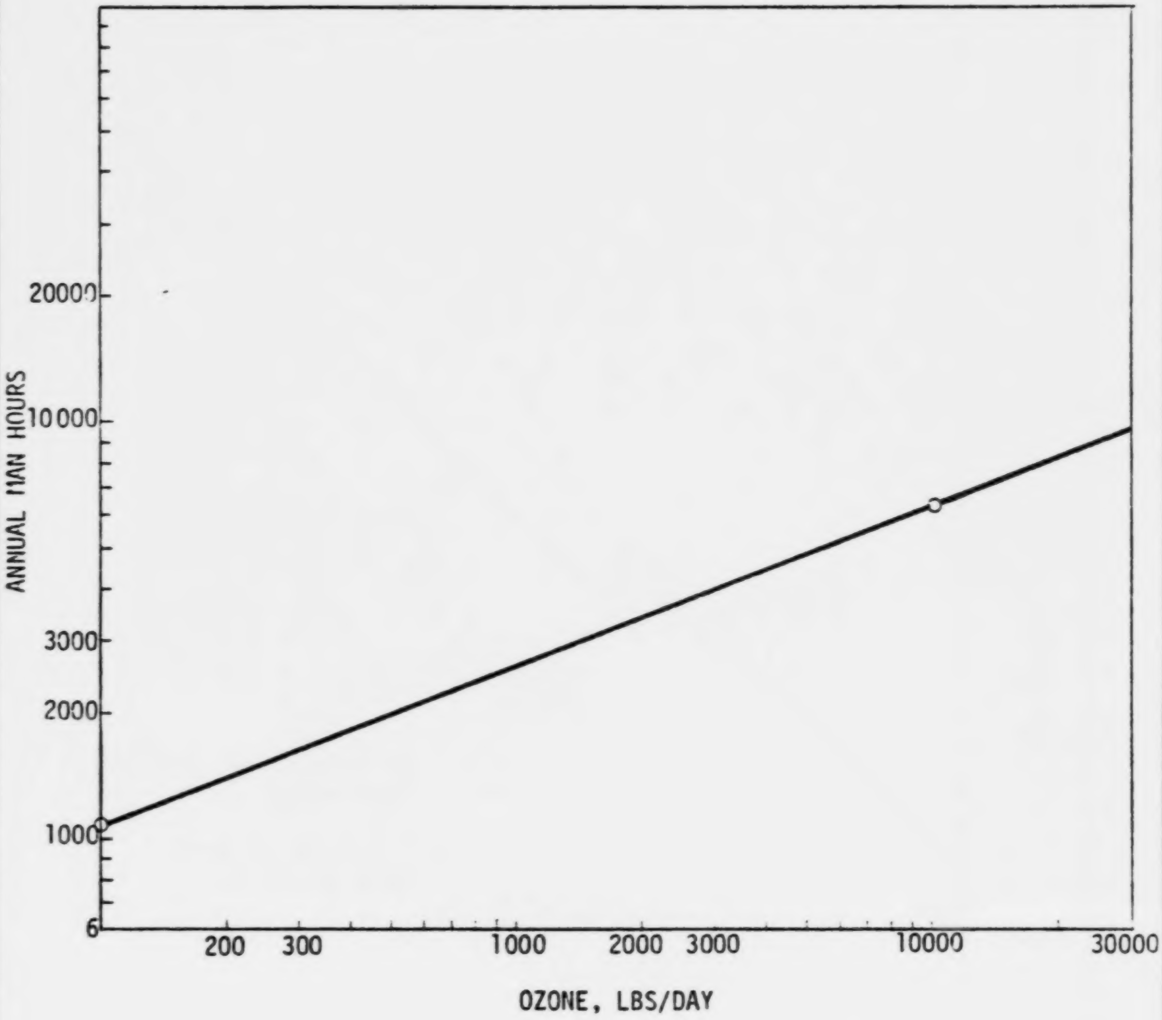
FIGURE D-3.1.4



CURVE BASED ON 7% ATTRITION AND VIRGIN CARBON COST OF 56¢/lb AND REGENERATED CARBON COST OF 40¢/lb

GRANULAR CARBON ABSORPTION AND PUMPING

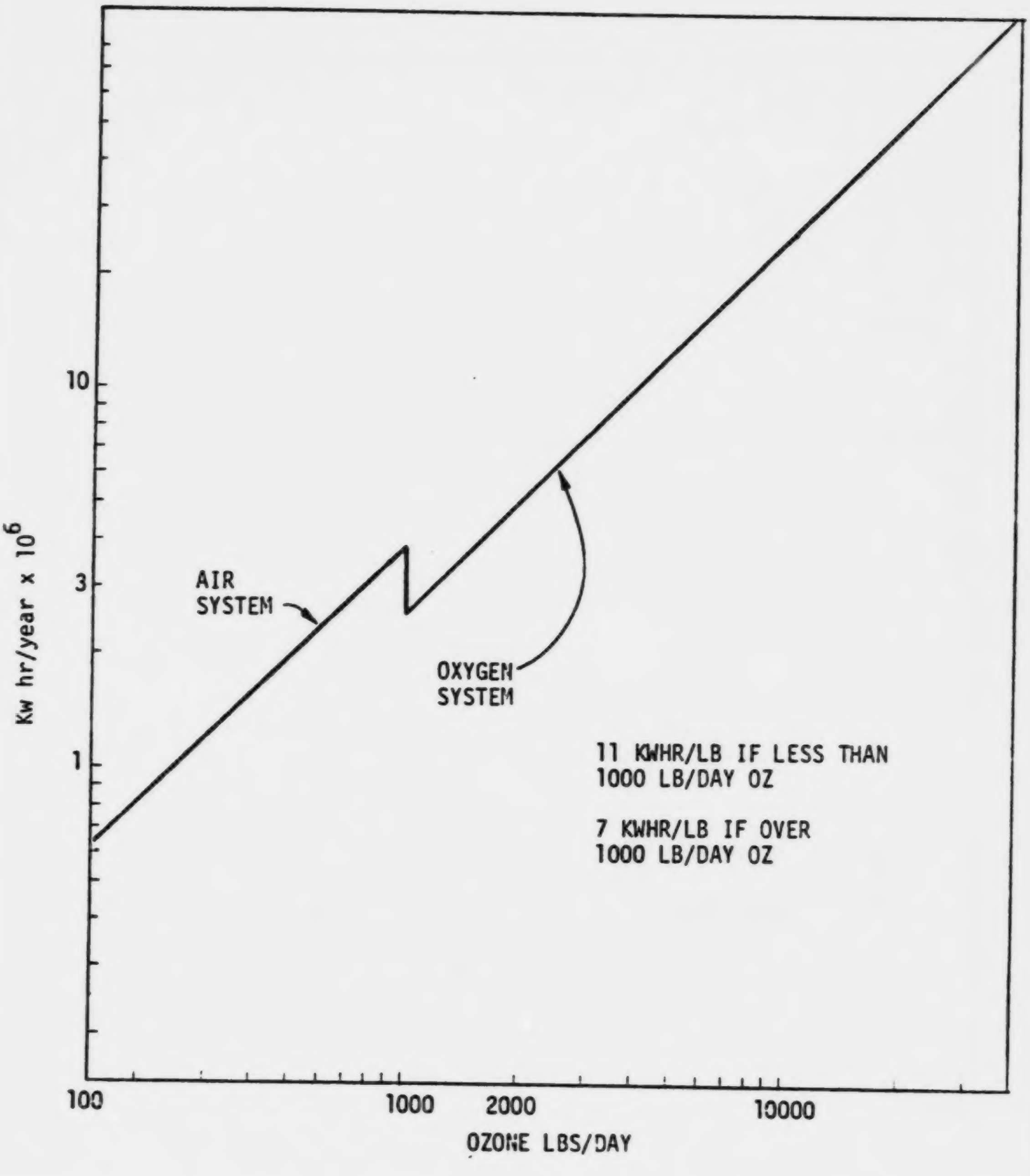
CARBON REGENERATION & MAKE-UP COSTS



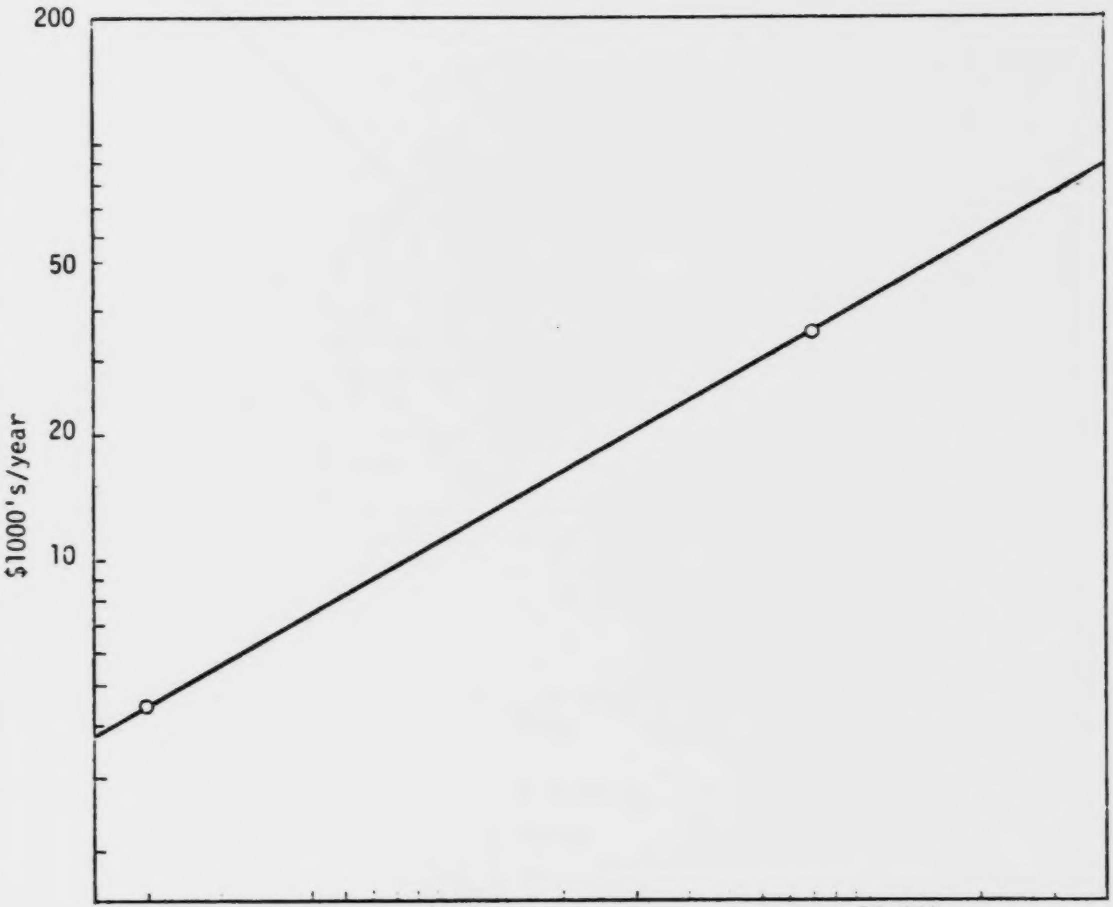
OZONATION

MAN-HOUR REQUIREMENTS

FIGURE D-4.1.2

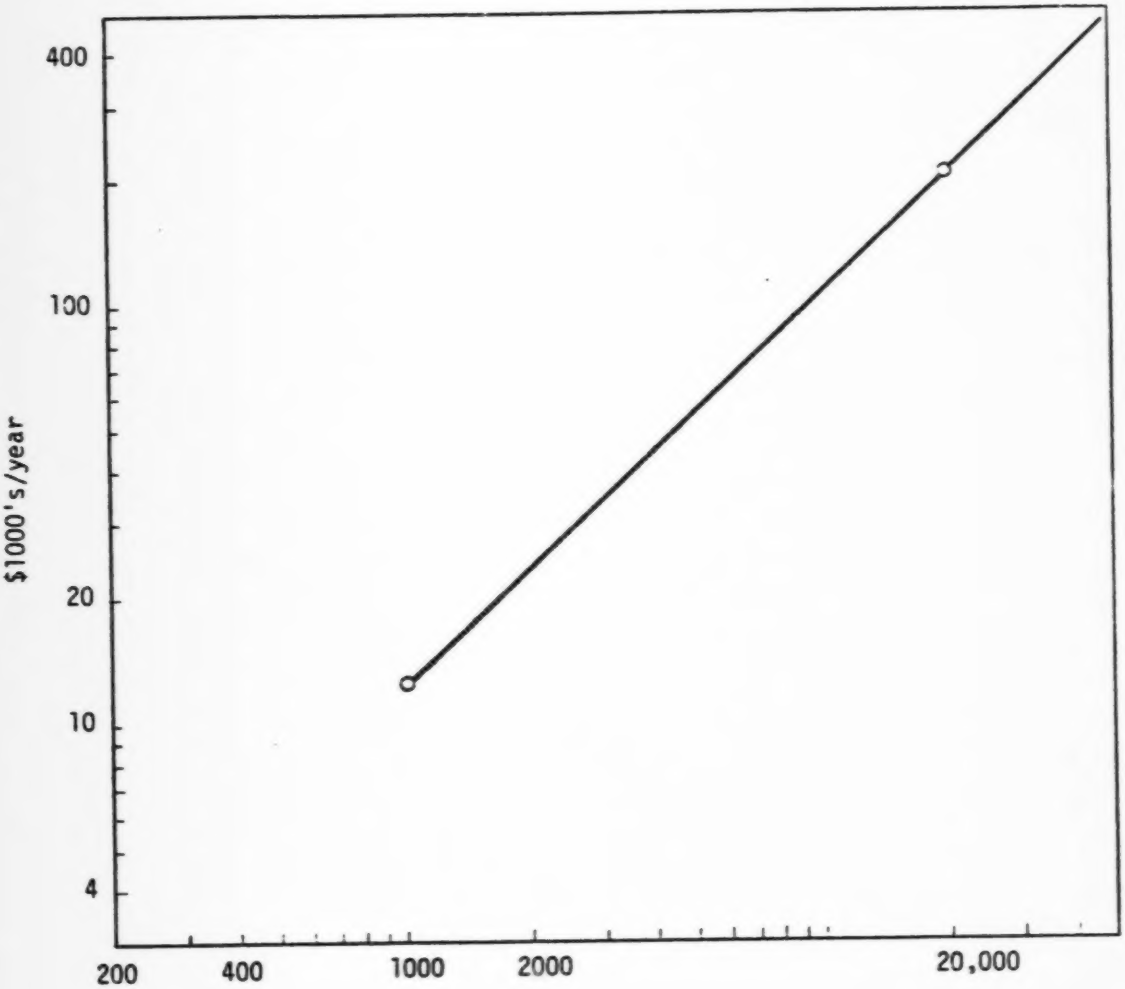


OZONATION - POWER REQUIREMENTS



OZONATION - MAINTENANCE MATERIAL COSTS

3% of capital



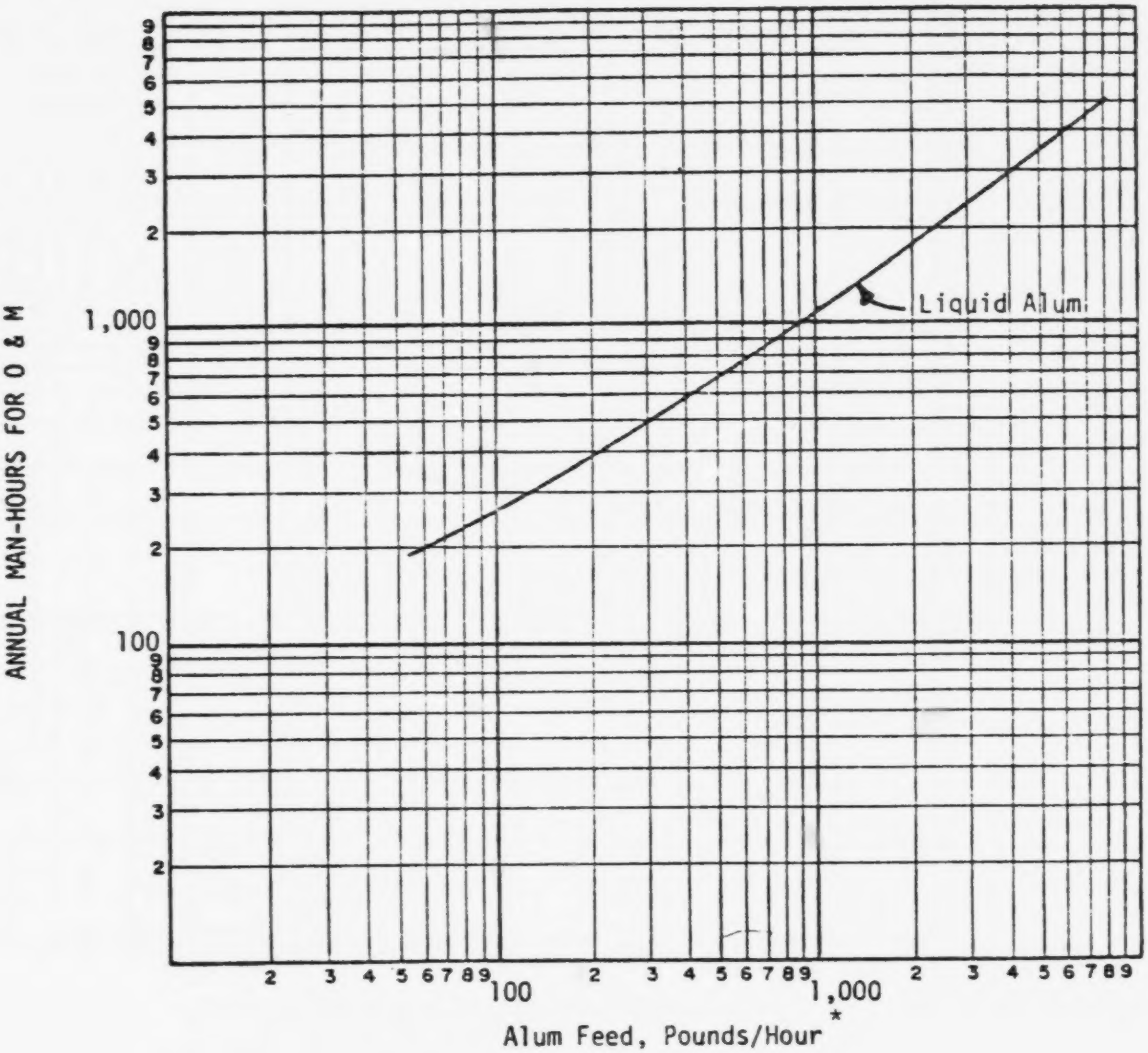
LBS/DAY OZONE

OZONATION

OXYGEN SUPPLY COSTS*

* These costs to be used only for oxygen system, & assume $.75 lb O_2/lb O_3$ and also assume cost of oxygen at $75/ton.

FIGURE D-5.1.1



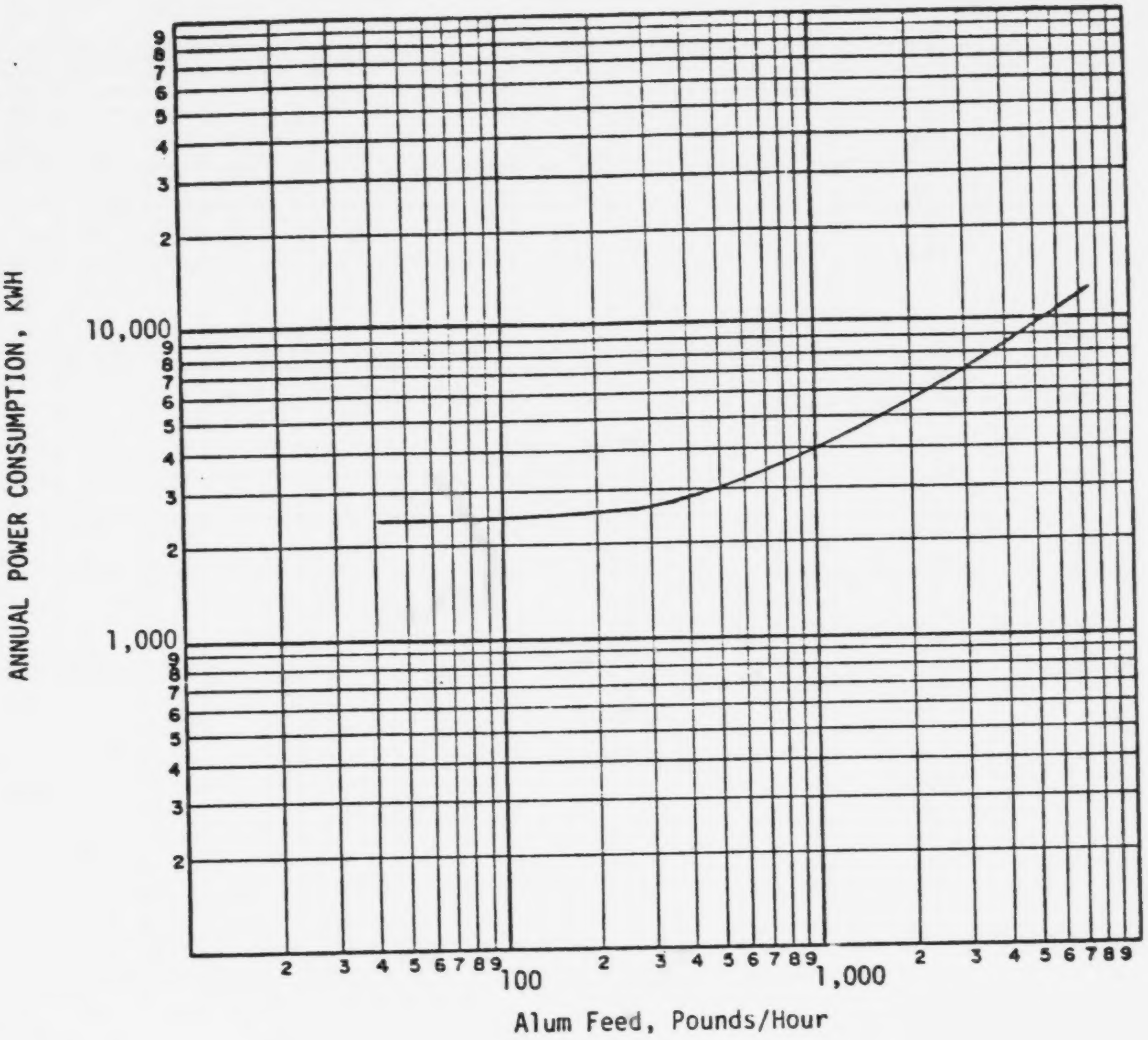
ALUM STORAGE AND FEEDING

MAN-HOUR REQUIREMENTS

To obtain lbs/hr as Alum feed, multiply feed rate in lbs/day as Al^{+3} from Table 1 by 11.1 and divide by 24 hrs/day.

Curve 82

See Figure D-1.1.1



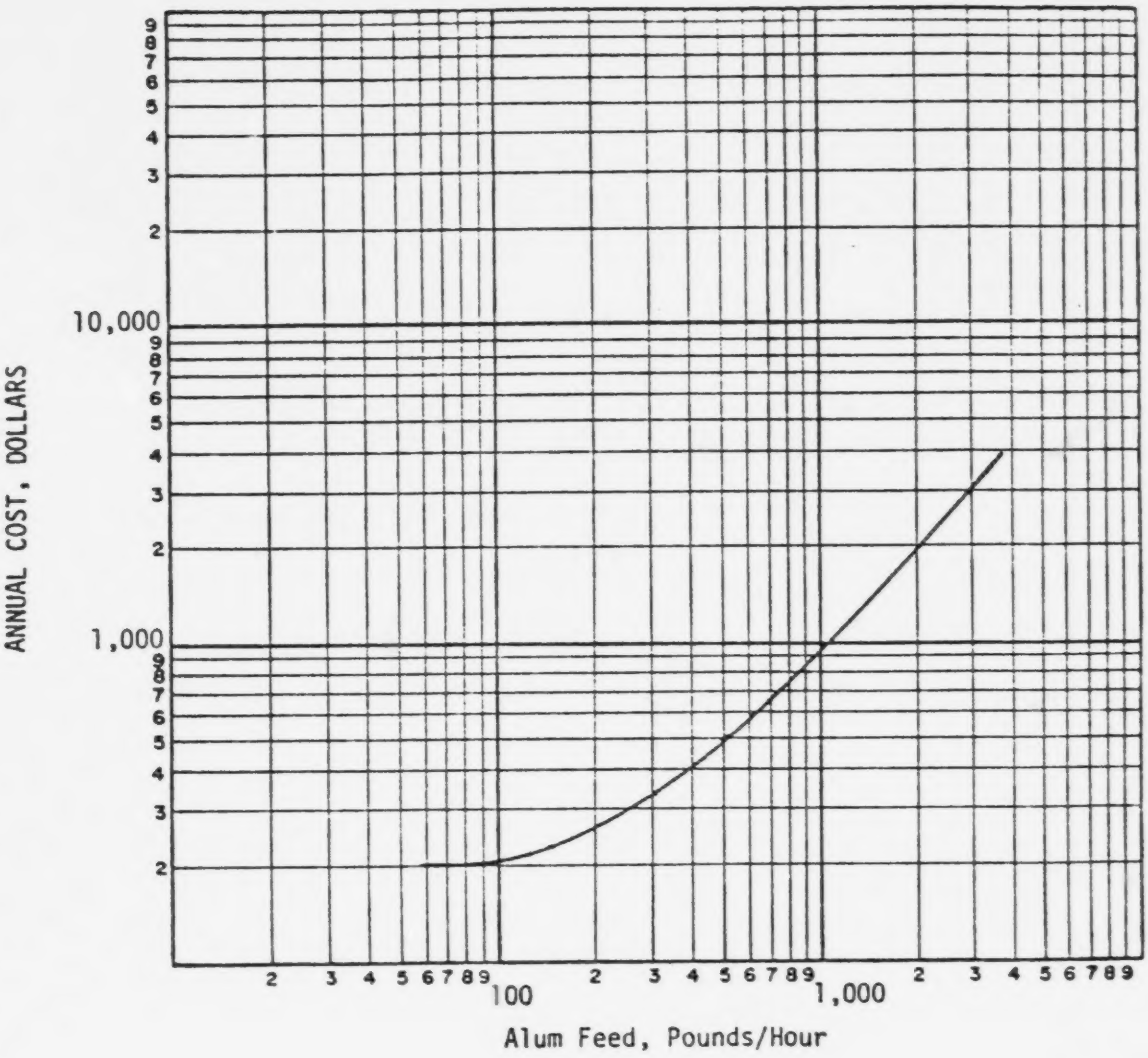
ALUM FEEDING

POWER REQUIREMENTS

Curve 83

See Figure D-1.1.1

FIGURE D-5.1.3



ALUM STORAGE AND FEEDING

MAINTENANCE MATERIAL COSTS

Curve 84

See Figure D-1.1.1

1. LOCAL COST OF ALUM $_________/LB

2. DAILY ALUM USAGE _______LB/DAY
   (FROM TABLE I, PAGE ii)

3. ANNUAL CHEMICAL COST = LBS/DAY X 365 DAYS/YR
   X LINE 1.

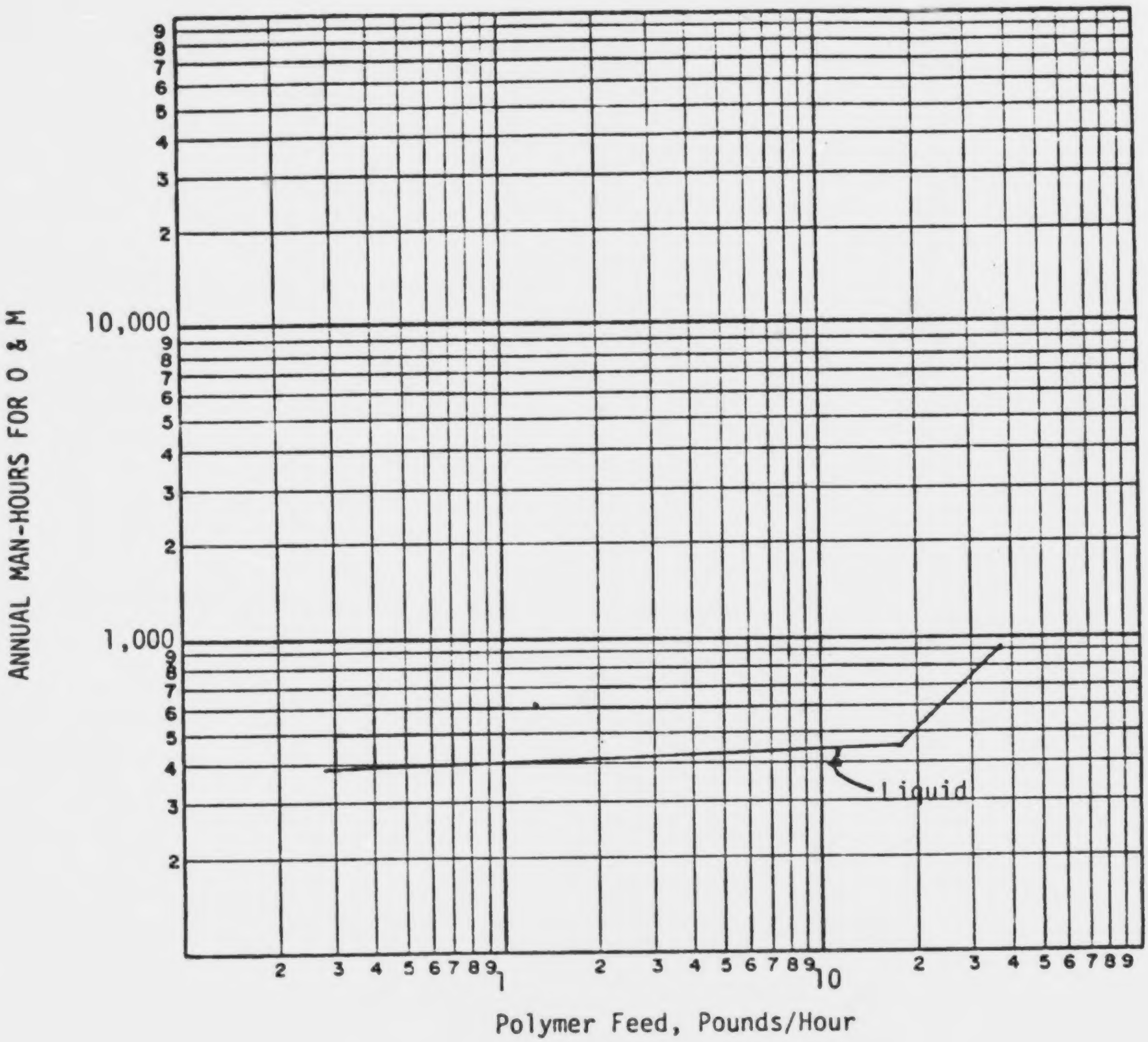
_________LB/DAY X 365 DAYS/YR X $__________/LB =

$____________ PER YEAR

ALUM STORAGE AND FEEDING

CHEMICAL COSTS

FIGURE D-5.2.1



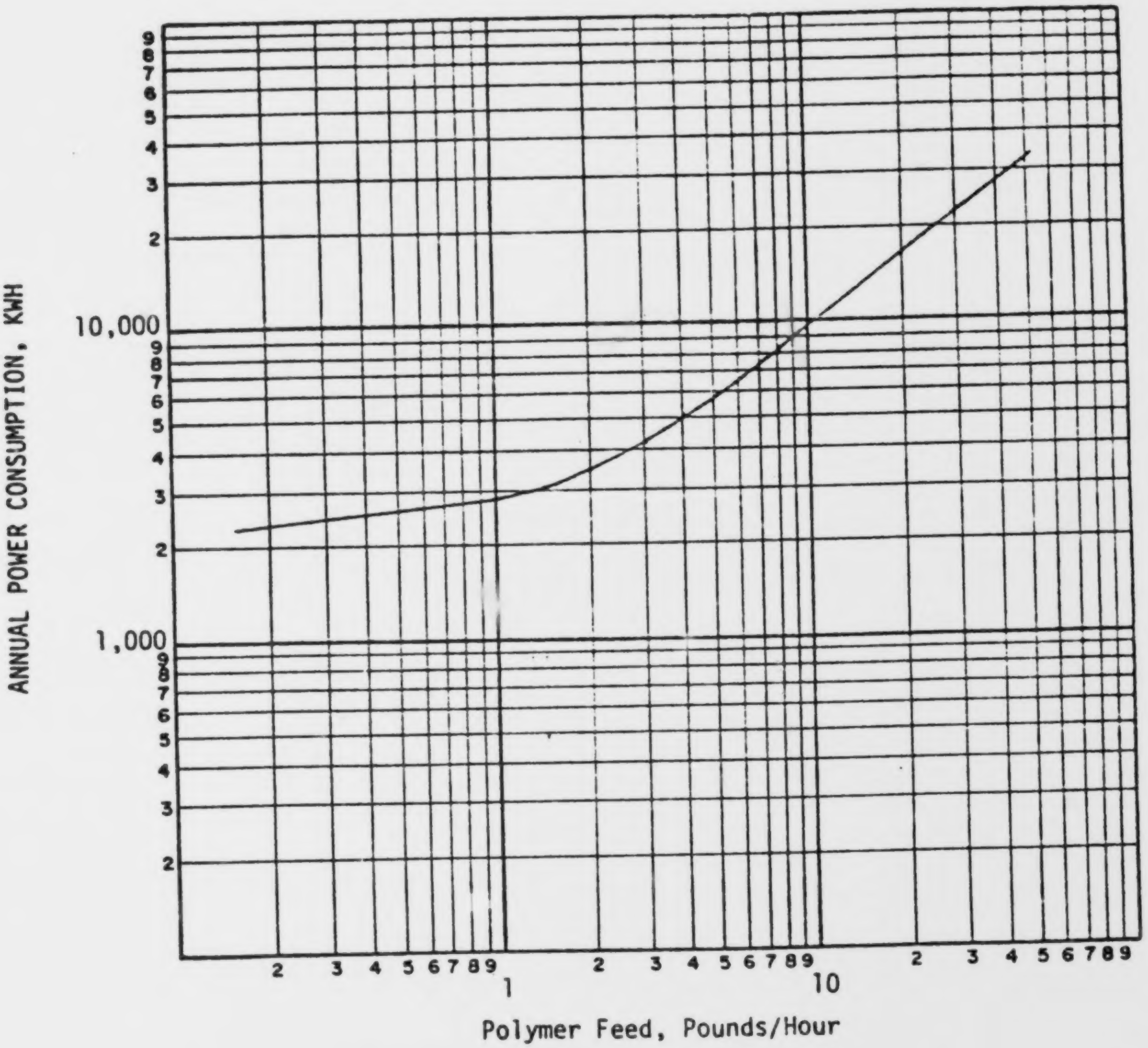
POLYMER FEEDING

MAN-HOUR REQUIREMENTS

Curve 91

See Figure D-1.1.1

FIGURE D-5.2.2



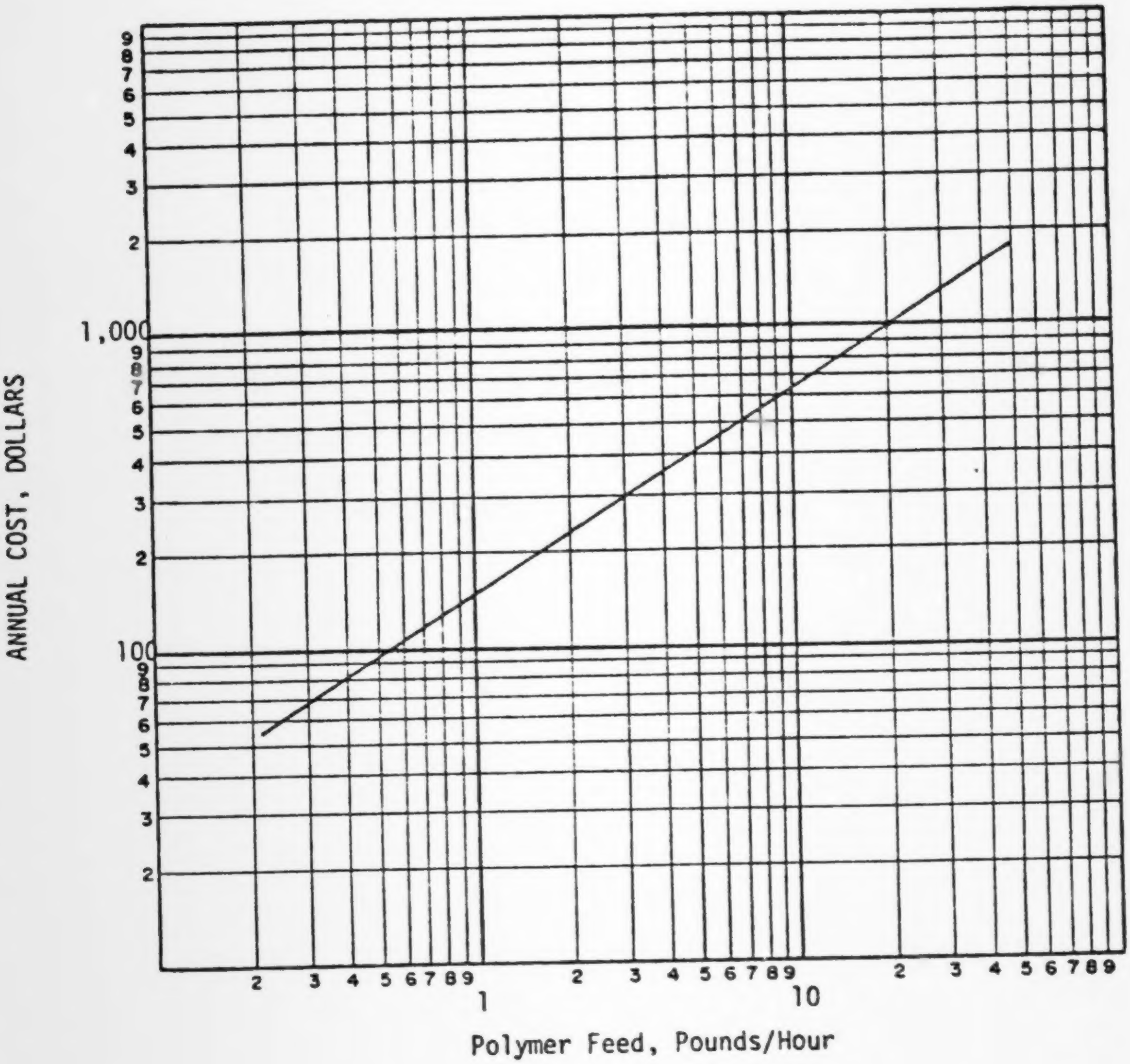
POLYMER MIXING AND FEEDING

POWER REQUIREMENTS

Curve 9

See Figure D-1.1.1

FIGURE D-5.2.3



POLYMER STORAGE AND FEEDING

MAINTENANCE MATERIAL COSTS

Curve 93

See Figure D-1.1.1

1. COST OF POLYMER (ASSUME $0.60/LB)
2. DAILY POLYMER USAGE ________LB/DAY (FROM TABLE I, PP ii)
3. ANNUAL CHEMICAL COST

POLYMER, LBS/DAY X 365 DAYS/YR X COST ($0.60/LB)

________LB/DAY X 365 DAYS/YR X $0.60/LB =

$__________PER YEAR

NOTE: 60¢/lb is based on vendor quotes for the polymer used during testing.

POLYMER FEED

CHEMICAL COSTS

FIGURE D-15

ADDITIONAL BPT O & M COST

1. ENTER THE ANNUAL O & M COST FOR YOUR EXISTING

BPT FACILITY $____________ PER YEAR

2. ADDITIONAL BPT O & M COST

= % ADDITIONAL BPT FLOW X LINE 1

$$= \frac{\text{BACKWASH FLOW}}{\text{AVG BPT FLOW}} \text{ X LINE 1}$$

$$= \frac{\_\_\_\_\_\_\_\_\_\_\text{ MGD}}{\text{MGD}} \text{ X \$}\_\_\_\_\_\_\text{/YR = \$}\_\_\_\_\_\_\_\_\_\text{/YR}$$

ADDITIONAL INFORMATION

You are requested to complete the following information to help us evaluate your process design and cost estimate packages.

1. What was the average production value you selected for your Process Selection and Process Design Package? __________lbs/day

2. When you apply for a permit you will likely use a greater production value than the one listed above. The EPA definition for average production when applying for an NPDES permit is as follows:

   AVERAGE QUANTITY PER DAY PRODUCED AT HEAVIEST PRODUCT MIX DURING A MONTH OF MAXIMUM PRODUCTION WHICH IS REPRESENTATIVE OF THE EXPECTED LEVEL OF ACTIVITY CONTRIBUTING TO THIS DISCHARGE. LEVELS OF PRODUCTION MAY BE OBTAINED FROM ACTUAL OPERATING RECORDS OR EXPECTED PRODUCTION LEVELS BASED ON MARKET PROJECTIONS.

   What would be your average production according to this permit definition? _________lbs/day

3. Is your plant located on a water quality limited stream that has more restrictive permit values than what is allowed by the BATEA guideline values? Yes No (Circle One)

   If so, what are the more restrictive parameters and values.

4. What percent of your present waste treatment plant design capacity is being utilized? ______%

5. Is your present waste treatment plant achieving BPT guideline values?

   Yes No (Circle One)

BPT QUESTIONNAIRE

1. Draw a simple flow diagram of your waste treatment system.

2. What is the average flow rate in MGD of the raw waste?

____

3. What is the design flow rate in MGD of the treatment system?

____

4. If aerated, what horsepower is used for aeration?

____

5. What is your best estimate of aeration time in hours?

____

6. What is your sludge removal rate in lbs. per day?

____

7. What is the pH of the raw waste entering the system?

____

8. If known, what is the current depth of sludge in the basin?

____

9. If known, what is the volume of the aeration basin?

____

10. What is the sludge recirculation rate?

____

Definition for Commission Finishing Referred to on Page 4.

"Commission Finishing shall mean the finishing of textile materials, 50 percent or more of which are owned by others, in mills that are 51 percent or more independent (i.e. only minority ownership by companies with greige or integrated operations); the mills must process 20 percent or more of their commissioned production through batch, non-continuous processing operations, with 50 percent or more of their commissioned orders processed in lots of 50,000 yards or less."

APPENDIX G

GLOSSARY OF TERMS

ADMI: American Dye Manufacturers Institute

AFLOW: actual flow

AL: alum

Al: aluminum

AP: anionic polymer

ATMI: American Textile Manufacturers Institute

Avg: arithmetic mean (average)

AWT: Advanced Wastewater Treatment

BATEA: Best Available Technology Economically Achievable

B.D.L.: below detectable limits

BOD: 5-day 20°C Biochemical Oxygen Demand (mass or concentration)

BOD_5: 5-day 20°C Biochemical Oxygen Demand (mass or concentration)

BPT: Best Practicable Treatment

B.W.: back wash

BWR: back wash rate

BWT: back wash time

C: composite sample

C: concentration

°C: temperature in degrees centigrade

C_o: initial concentration

Cr_T: total chromium (mass or concentration)

CAT.: cationic polymer

CC: carbon columns

CHEM: added chemical

CHEM RT: chemical dosage

CHR: total chromium (mass or concentration)

CMC: carboxy methyl cellulose

COD: Chemical Oxygen Demand (mass or concentration)

COD_S: Soluble Chemical Oxygen Demand (mass or concentration)

CP: cationic polymer

CRI: Carpet and Rug Institute

D: diameter

D: magnitude of change in a given parameter

d_t: hydraulic detention time

DAF: dissolved air flotation

DUP: duplicate sample

EFF: effluent flow

EPA: U.S. Environmental Protection Agency

ES: Engineering-Science, Inc.

Exp: experiment

EXPER: experiment

FC: ferric chloride

FLOW: nominal flow

ft: length in feet

G: grab sample

G: mean velocity gradient

gal: volume in gallons

gpd: flow rate in gallons/day

GPM: flow rate in gallons/minute

HL: head loss

hr: time in hours

HRT: hydraulic residence time

H_2SO_4: sulfuric acid

IBM: International Business Machines

ICI: ICI United States, Inc.

ID NUM: identification number

K_T: propeller drag coefficient

KI: potassium iodide

LAB: laboratory code

lb: mass in pounds

LOC: sampling location

LTGT: less than or greater than

M: mass of activated carbon

Max: Maximum

MCRT: mean cell residence time

MG: million gallons

MGD: flow rate in million gallons/day

mg/l: concentration in milligrams/liter

MILL: textile mill code

min: time in minutes

MLSS: mixed liquor suspended solids

MLVSS: mixed liquor volatile suspended solids

m/m: multi-media filter

mm: length in millimeters

MMF: multi-media filter

MPP: mobil pilot plant

N_n: natural production (n is assigned number specific for production type)

n: number of data points

N/A: not available

NaOH: Sodium hydroxide

nM: wave length in nano-meters

n.m.: not measured

NTA: Northern Textile Association

O_3: ozone

O_z: ozone

OBS: observation number

OZ: ozone

OZUTIL: ozone utilization fraction

P: power input

PA: Polymer A

PAA: poly acrylic acid

PB: Polymer B

PCI: PCI Ozone Corporation

pH: $\log_{10}$ (H^+ concentration, moles/l)

PHE: Phenol (mass or concentration)

ppm: parts per million

PRE-COAG: pre-filter coagulant

pri: primary

psig: gauge pressure in pounds/square inch

PVA: Poly-Vinyl Alcohol

PVC: Poly-Vinyl Chloride

R/C: reactor/clarifier

RCUR: reactor/clarifier underflow rate

REF: reference sample

REM: removal

RPM: rotational speed in revolutions/minute

S_n: synthetic production (n is assigned number specific for production type)

S_n/N_n: synthetic/natural blend production (n is number specific for production type)

sec: secondary

sec: time in seconds

SF: area in square feet

SOD: Soluble Chemical Oxygen Demand (mass or concentration)

SPK: spike sample

SUL: Sulfide (mass or concentration)

SQ FT: area in square feet

%T: percent transmittance

T_n: total production (n is assigned number specific for production type)

TMP: temperature

TOC: Total Organic Carbon (mass or concentration)

TRA: percent transmittance

TSS: Total Suspended Solids (mass or concentration)

TUR: percent transmittance

U: factor for determination of required number of observations

V: volume

WV: Westvaco

QA: quality assurance

X: mass TOC removed

$\bar{X}$: arithmetic mean

Z: enhancement factor

α: acceptable risk

β: acceptable risk

μ: dynamic viscosity

σ: standard deviation

APPENDIX H

COMMON UNIT/SI UNIT CONVERSION TABLE*

AREA

1 acre = 4.0469×10^{3} metre^{2}
1 foot^{2} = 9.2903×10^{-2} metre^{2}
1 inch^{2} = 6.4516×10^{-2} metre^{2}
1 mile^{2} = 2.5900×10^{6} metre^{2}
1 yard^{2} = 8.3613×10^{-1} metre^{2}

ENERGY

1 British thermal unit (mean) = 1.0559×10^{3} joule
1 foot-pound-force = 1.3558×10^{0} joule
1 kilowatt-hour = 3.6000×10^{6} joule

FLOW

1 foot^{3}/minute = 4.7195×10^{-4} metre^{3}/second
1 foot^{3}/second = 2.8317×10^{-2} metre^{3}/second
1 gallon (U.S. liquid)/day = 4.3813×10^{-8} metre^{3}/second
1 gallon (U.S. liquid)/minute = 6.3090×10^{-5} metre^{3}/second

FORCE

1 pound-force = 4.4482×10^{0} newton

LENGTH

1 angstrom = 1.0000×10^{-10} metre
1 foot = 3.0480×10^{-1} metre
1 inch = 2.5400×10^{-2} metre
1 mile = 1.6093×10^{3} metre

MASS

1 grain = 6.4799×10^{-5} kilogram
1 pound-mass = 4.5359×10^{-1} kilogram
1 slug = 1.4594×10^{1} kilogram
1 ton (2000 lbm) = 9.0718×10^{2} kilogram

POWER

1 BTU/hour = 2.9307×10^{-1} watt

1 foot-pound-force/hour = 3.7662×10^{-4} watt

1 horsepower (550 ft-lbf/s) = 7.4570×10^{2} watt

PRESSURE

1 atmosphere (normal) = 1.0133×10^{5} pascal

1 foot of water (39.2°F) = 2.9890×10^{3} pascal

1 inch of mercury (32°F) = 3.3864×10^{3} pascal

1 pound-force/inch^{2} = 6.8948×10^{3} pascal

VOLUME

1 foot^{3} = 2.8317×10^{-2} metre^{3}

1 gallon (U.S. liquid) = 3.7854×10^{-3} metre^{3}

1 litre = 1.0000×10^{-3} metre^{3}

*All conversion factors are rounded off to 5 significant digits.